OPERATIVE SURGERY

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WITH 613 ORIGINAL ILLUSTRATIONS

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ST. LOUIS
C. V. MOSBY COMPANY
1921

Printed in U.S.A.

Press of
C. V. Mosby Company
St. Louis

THIS VOLUME IS AFFECTIONATELY
DEDICATED TO
MY EIGHT CHILDREN

PREFACE

In this book particular stress has been laid upon the preservation of physiologic function and the interpretation of the biologic processes that follow surgical operations.

Naturally, a knowledge of anatomy is essential for operative surgery, but in many regions of the body an effort to conserve or to restore as far as possible the physiologic function of the tissues involved in the operation has often been neglected. Merely following anatomical landmarks and making a beautiful dissection with accurately placed ligatures and sutures should not be the sole aim of the surgeon. These things, of course, should be included in the surgeon's ideals, but it is even more important that the operation results in the extirpation or correction of the pathology, and in the restoration of the physiology of the tissues or organs. One of the chief aims of this book is to emphasize those physiologic and biologic principles which, to some extent, obtain in every surgical operation.

The biologic processes that follow the application of surgical drainage, for instance, have been too frequently not considered at all and surgical drainage has been regarded as solely or chiefly mechanical. The treatment of fractures by metal plates or screws produces excellent immediate mechanical results, but a little study of the biologic processes following the use of metal plates should convince the surgeon that this is not a satisfactory operation. Physiologic principles, if logically followed, in operations for ulcer of the stomach and for resection of the intestine, appear to lead to certain definite technics, even though others may be anatomically and mechanically unobjectionable. The development of collateral circulation around an aneurism by partial or intermittent occlusion of the artery, as has been practiced by Halsted and by Matas, is often a much safer procedure than the immediate and permanent occlusion of the vessel. Developing a blood supply in the pedicle of a flap by the gradual dissection of the flap in different stages, insures against gangrene and makes possible better plastic results because it brings more nutrition to the reconstructed tissues. There are many other examples that might be cited.

No attempt has been made to include in this volume all surgical operations. Such an enclycopedia of operations is found in many excellent text books and systems of surgery. Every operation that I have described is either one that I have done or else an operation that appears to me to be the one best suited for the disease. Frequently, conditions are such that different operations may be indicated for what appears to be the same affection. In order to meet this situation, I have often described several operations, each one of which I believe, under certain conditions, would be appropriate. In this way the book is to a considerable extent a record of my personal experience.

All of the drawings are by Miss Helen Lorraine, except the illustrations of Dr. J. W. Long's enterostomy, which were drawn by William F. Didusch.

It is a pleasure to acknowledge my obligation to Mrs. A. C. Norris, my former secretary, who, in spite of her domestic duties, consented to help in the preparation of the manuscript for this book. She has greatly lightened the labor of its preparation.

My thanks are due Dr. W. T. Graham for many helpful suggestions about the sections dealing with orthopedic surgical operations.

J. Shelton Horsley.

Richmond, Va.

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OPERATIVE SURGERY

CHAPTER I

GENERAL CONSIDERATIONS*

Surgical operations are performed on living tissues and must be considered with regard to physiology and pathology in the living as well as from an anatomical point of view. Operations that look well on a cadaver will sometimes be unsuccessful on a patient. A beautiful operation that results in the death of the patient is not satisfactory surgery. While the mechanics of a surgical operation is important, it should not entirely dominate the situation. The object of a surgical operation is to save life, to relieve pain, and to restore function, and these three things in the order named should always be kept in mind. The technic of an operation should be chosen not solely because it appeals to a mechanical sense, but because it is biologically correct. The changes and reactions of tissues after operation must be borne in mind when selecting the technic for any surgical procedure.

It cannot be too often emphasized that surgery should be more a science than an art. A surgeon who is a dexterous operator and who skilfully amputates a leg that with patience and scientific application could be saved, is merely a good artisan, and is distinctly inferior to the surgeon who could save the leg even though he should be a bungling operator. The ideal is to be thoroughly imbued with the principles of the biologic sciences, thoughtfully to apply these principles, and at the same time to be mechanically skilful.

The science of anatomy is essential to the mechanics of surgery. He would be a poor locomotive mechanic who did not understand the construction of his engine; and in operations on the neck, for instance, a surgeon who is ignorant of anatomy would be like the proverbial bull in a china shop. A knowledge of anatomy is essential to good surgery, but in the ever shifting problems of tissue repair and metabolism, physiology is just as necessary. The principles underlying an operation are correct only if they conform to the laws of physiology and to the laws of repair of the tissue or organ that is affected. If we could get away from blindly following what some one says merely because he says it, and do things because of reasons that have sound biologic foundations, we should undoubtedly do work more satisfactory to our patients and to ourselves.

Let us take an illustration from the practical work of a surgeon and see

*Much of this chapter is from a paper entitled "The Value of Biologic Principles in Surgical Practice." Horsley, J. Shelton: Jour. Am. Med. Assn., May 3, 1919.

how thoughtful application of physiologic principles would have rendered a problem that appeared difficult easier to solve. Hyperemia is connected in one way or another with all surgical questions, whether they concern treatment of inflammation or repair of a wound. It has long been known that blood is an enemy of the tubercle bacillus, and that obtaining a good supply of healthy blood is the only satisfactory method of combating tuberculosis. About two decades ago when a patient with tuberculous peritonitis and ascites sought surgical treatment he might have been subjected to one of several procedures. One surgeon would have advised opening the abdomen and letting the sunlight in; another thought it was best to dust the intestine with some special powder; still another believed in drainage with a single tube, others with multiple tubes. All these methods secured more or less satisfactory results. Each surgeon, seeing his patient recover after using his own method, earnestly thought that this was the only correct procedure. The situation resembled very much that described in a poem in an old school reader in which four blind men went to see an elephant. One fell against its side and thought the elephant was like a wall; another embraced a leg and declared it resembled a tree; the third grasped its tail and said the animal was constructed like a rope, and the last felt a tusk and concluded that the elephant was very like a spear. The moral was that though each was partly in the right they all were in the wrong. So all of these surgeons who were using different methods were unconsciously working on a principle that produced hyperemia, and it was this hyperemia, induced partly by draining off the fluid and so relieving pressure, and partly by handling the intestines, that cured the tuberculosis. It was many years, however, before this fact was acknowledged by the various partisans.

The surgical treatment of slow or threatened gangrene has also been much discussed. Carrel and Guthrie,[1] after two experiments, concluded that the blood circulation in the leg of a dog could be completely reversed within six hours. They severed the femoral artery and vein just below Poupart's ligament and united by suture the cardiac end of the artery to the distal end of the vein, and the distal end of the artery to the cardiac end of the vein. After a few hours, when red blood was seen returning, they assumed that the circulation was reversed. I think it can now be stated, however, that it is impossible to reverse the circulation in this manner. In a series of experiments which have been reported elsewhere,[2] we have shown that when the severed femoral artery and vein of animals are sutured together in a reversed direction there is no real reversal of the circulation, and the arterial blood never goes more than a short distance below the knee and is then quickly switched back to the iliac veins through the dilated collateral vessels. Evidently what happened in Carrel's experiments was that dissection paralyzed the vasoconstrictor nerves, and the dilated capillaries permitted red arterial blood

[1]Carrel, Alexis, and Guthrie, G. C.: Ann. Surg., 1906, xliii, 203-215.
[2]Horsley, J. S., and Whitehead, R. H.: A study of Reversal of the Circulation in the Lower Extremity, Jour. Am. Med. Assn., March 13, 1915, lxiv, 873-877.
Horsley, J. S.: Reversal of the Circulation of the Lower Extremity, Ann. Surg., March, 1916, lxiii, 277-279.

to flow through unchanged. When the sciatic and crural nerves are divided in a dog, red blood appears in the femoral vein because of the extreme dilatation of the capillaries. Clinically this is often seen to follow an application of the elastic tourniquet which, if left on for even a short time and then removed, produces an intense flushing of the limb until the temporarily paralyzed vasoconstrictors have resumed their function. Many useless operations have been done attempting so-called reversal of the circulation in threatened gangrene. The only good accomplished was damming back the venous blood and forcing the small amount of arterial blood that reached the tissues to stay longer than it normally would, and so deliver to the tissues more nutrition than would be possible when the arterial blood was quickly drained off by unobstructed veins. This can be very simply effected by ligating the femoral vein.

Surgery of the gastrointestinal tract suffers from the lack of application of physiologic principles. Take, for example, the popular operation of gastroenterostomy. It does relieve the symptoms of many patients with duodenal or gastric ulcer. Many, however, still have their symptoms, and restoration of the normal channels by undoing a gastroenterostomy is an operation not infrequently performed. The cases that are cured by gastroenterostomy have never been fully explained. Some say it is a drainage operation, and yet in draining other hollow viscera we do not open at the lowest point. We drain the gall bladder and the urinary bladder from the part opposite the most dependent portion, and we do an enterostomy in the distended loop of bowel that is nearest the incision, because we know that normal contraction or peristalsis will keep the bladder or bowel empty if an opening is made. By some it is claimed that gastroenterostomy cures because the acidity of the gastric juice is lessened, and still others assert that by short circuiting the course of food, rest is given the ulcer; yet roentgenoscopy reveals that unless the pylorus is closed a considerable portion of food continues to go by this route, and no pyloric closure seems to be permanent unless a resection is made.

Recent physiologic research by Cannon and Washburn,[3] which has been confirmed by Carlson[4] and others, has demonstrated that the hunger pains, or so-called pangs of hunger, in a normal stomach are due to excessive peristaltic contractions of the stomach. It has also been shown that the pains that come on with clocklike regularity after meals in duodenal or gastric ulcer, are not produced by acid erosion of the ulcer by the hyperacid gastric juice, as was formerly taught, but are due to the contraction of peristalsis on gastric nerves made sensitive by the inflammation of the ulcer. The character of the gastric juice has nothing to do with the pain except so far as it excites an abnormal amount of peristalsis. Food or sodium bicarbonate lessens peristalsis for a while and so relieves pain. Investigation seems to show that the stomach has a limited

[3]Cannon and Washburn: An Explanation of Hunger, Am. Jour. Physiol., 1912, xxix, 441.
[4]Carlson, A. J.: The Control of Hunger in Health and Disease, University of Chicago Press, 1916, pp. 62-83.

supply of nerves that conduct pain,[5] and these nerves, which are deep in the stomach wall, are made more sensitive than normal by the inflammation around an ulcer. Consequently, they register impulses of pain from the pressure of peristalsis that in a normal physiologic condition they would not register. It is probable that gastroenterostomy relieves pain by facilitating the emptying of the stomach and so lessening peristalsis. This, however, is largely the treatment of a symptom and not an effort to remove a pathologic condition and to restore tissues to their physiologic state.

In the surgery of the intestine, the work of Cannon and Murphy in their studies of peristalsis after resection of the bowel has not received proper attention. Lateral anastomosis is still the method employed by many surgeons, though, as shown by Cannon and Murphy, peristalsis is practically abolished in the region of such an anastomosis. Food can be pushed through only when a column of it extends into a proximal (oral) loop where peristalsis is unimpaired. Postmortems in dogs with lateral anastomosis showed that there was always an accumulation of food at the site of the lateral anastomosis even when the rest of the intestinal tract was free, because severing the circular fibers, in this operation, abolished peristalsis, and the blind pouches could not be completely emptied. They found that in an end-to-end union there was not the slightest stasis of intestinal contents at the site of operation. Merely because the lateral union usually gives no disagreeable symptoms, its use has been continued. If the patient did not die it was assumed that he had sufficiently recovered. With attention to the triangular mesenteric spaces and careful closure of these and of other raw surfaces before the bowel is opened, together with disinfection of the bowel ends after opening, as good technical results are obtained in end-to-end union as after the lateral method, with the advantage of securing normal peristalsis and normal emptying.

There are many problems in neurologic surgery that require some knowledge of physiologic principles in order to be settled satisfactorily. Spiller and Frazier have demonstrated that section of the posterior sensory root of the gasserian ganglion produces what is called "physiologic extirpation" of the gasserian ganglion. It has been known for years that a nerve which is injured on the central side of its ganglionic cells does not regenerate; yet when the operation of division of the posterior sensory root for tic douloureux was suggested, it was received with some skepticism. This operation is safer than surgical extirpation of the gasserian ganglion, and is followed by less trophic disturbance. The plugging of foramina in the skull from which neuralgic sensory nerves have been removed in order to prevent regrowth of the nerves, has sometimes been done with metal screws. Because an iron screw can stop a hole in a piece of wood is not necessarily a reason why it should be employed in living tissue. On the other hand, some substance that does not cause reaction in bone is preferable. What happens after an iron screw is applied? Nature in an effort to extrude the irritating substance removes

[5] Kast and Meltzer: Med. Rec., New York, lxx, 1017; Ritter: Zentralbl. f. Chir., 1908, xxxiv, 609. Langley: Brain, 1903, xxvi, 23.

lime salts in its neighborhood, the bone softens, the screw becomes loose, and the nerve can grow around it.

The history of surgery of hydrocephalus contains many illustrations of the neglect of the appreciation of biologic principles in surgical operations. Various operations for this disease have been based upon an effort to secure drainage from the ventricles of the brain into the tissues of the neck with the idea that the excessive cerebrospinal fluid would be absorbed from this region. Tubes and threads of various kinds have been run from the lateral ventricle through the skull and into the tissues of the neck or scalp. There seems to have been very little consideration of how the absorption would take place after the mechanical features of the operation had been completed. It is obvious that a continuous injection of even a nonirritating fluid, such as salt solution, beneath the skin, produces after the course of a few days, an exudate which, to a large extent, blocks the lymphatics and greatly retards absorption. When this takes place, it is only possible to cause the fluid to be absorbed by greatly increasing the pressure. Such pressure, if produced in the brain, would be fatal from compression of the brain. Consequently, even if the cerebrospinal fluid could flow unobstructed from the ventricles of the brain through a tube or along threads into the neck, the intracerebral pressure necessary to force absorption would soon be so great as to impair the function of the brain. The reason that such operations are sometimes successful is because they do not drain as they are supposed to do, but incidentally provide for the increased pressure of fluid within the brain by the removal of a portion of the skull which is necessary for the operation. Such instances of permanent improvement, however, are few and far between.

The fashion for plating fractures fortunately is on the decline. Hundreds and probably thousands of fractures have been plated with heavy metal plates for no reason except that it appeals to the mechanical sense and because some eminent surgeons advocated this operation. In many cases it is followed by attempted extrusion of the plate which later has to be removed. To the casual observer it seems strange that permanent union does not always occur when a nice cabinet joint is made between the ends of a fractured bone and the ends are held securely in position by steel plates and screws. The same process goes on here as when an effort is made to plug a foramen in the bone with iron. The iron is an irritating foreign substance, and in order to extrude it, nature causes an absorption of the lime salts. As a result, a screw which may at first be firmly fixed in the bone soon becomes loose; but more important is the fact that osteoporosis is induced in this effort at extrusion, and callus formation is thereby prevented or retarded. A poorly fixed fracture without the use of metal is more likely to give eventual good results than the neatest union by heavy plates and screws.

That emotions have considerable bearing on the prognosis in certain cases of surgery has long been accepted. Cannon,[6] has demonstrated that

[6]Cannon, W. B.: Bodily Changes in Pain, Hunger, Fear and Rage, New York, 1915, D. Appleton & Co., pp. 52-80.

fright or profound anxiety causes a stimulation first of the sympathetics and then of the suprarenals. The action of epinephrin amounts to a prolonged stimulation of the sympathetic nervous system. Thus the body is put on what may be called a war basis, the circulation is more active, the heart beats faster, the pupils are dilated, respiration is accelerated, and metabolism generally is increased. Often there is so much glycogen released from the liver as to cause marked glycosuria, especially if the body is at rest; but if the emotions are accompanied by physical action, as fighting or running, this excessive amount of sugar may be consumed. The moral is that in some surgical cases it undoubtedly makes the prognosis better if emotions of fear or anxiety are allayed as much as possible. In diseases such as exophthalmic goiter, measures that abolish or diminish fear or excitement are of the greatest importance, and an operation should be so selected and performed as to carry out these indications.

Skin grafting and transplantation of organs or tissues are dependent on biologic laws. Surgeons who have had great experience in this type of work, such as Lexer,[7] and Davis, believe that skin grafts from others than the patient are practically never permanent. They either melt away at once, or if they appear to "take" are later absorbed and replaced by connective tissue. It has been suggested that tests, as for transfusion of blood, would be of benefit in selecting a donor for skin grafting; but so far this has not been put to any extensive practice. The transplantation of highly developed organs, such as a kidney, from one animal to another, even of the same species, is always a failure. The kidney may functionate for a while, but the fine biologic differences in the body fluids of the donor and the recipient cause degeneration, and the kidney eventually becomes a mass of connective tissue. This has been acknowledged by Carrel, Guthrie and others who were at one time enthusiastic about the success of such a procedure. The reconstruction of channels, as the bile ducts, from tissues that have no immunity to the irritating discharges with which they must come in contact is also unwise. Operations in which strips of fascia, pieces of vein[8] and other tissue unaccustomed to the action of bile are used, ultimately result in failure, no matter how skillfully the mechanical part of the operation is done.

These are merely a few instances of what every surgeon sees in his work, and they illustrate the profound influence that the application of biologic principles has on surgical practice. Real progress in surgery lies not so much in cultivating the art of surgery and in striving after mechanical dexterity, which is important but can be acquired in a few years, as in the study of biologic principles that concern function, nutrition, metabolism, and repair of tissues, and in the thoughtful application of these principles to every operation and to every method of surgical treatment.

[7]Lexer, E.: Ann. Surg., 1914, lx, 172-174.
[8]Horsley, J. S.: Reconstruction of the Common Bile Duct, Jour. Am. Med. Assn., October 12, 1918, lxxi, 1188-1194.

CHAPTER II

SURGICAL DRAINAGE*

The biologic defenses of the body against disease, trauma and the wear of age are wonderful, but they are not perfect. If they were perfect, man would live forever. Particularly interesting is the manner in which the body protects itself against injurious foreign substances. The epithelial lined body cavities have more or less specialized methods of protection. The stomach, for instance, by vomiting, emits food that is spoiled, and many drugs that are irritating or disagreeable to the taste, and sometimes even rejects substances that are thought to be nauseating or obnoxious even though they are not. The excessive salivation when nausea occurs probably tends to dilute the offensive material, or to protect the walls of the mucous membrane. Vomiting undoubtedly is a habit that was acquired in the early days of evolution. The more refined drugs or poisons that are a result of chemical manufacture have not created a similar defense by the stomach, and are often retained.

Foreign irritating substances in the rectum, the bladder or the larynx are also expelled by muscular action. Irritating matter in the nose causes a profuse secretion, which tends to wash away the offending substance. An irritating foreign body in the eye causes at once a flow of tears in an effort to wash it away, and at the same time the spasm of the muscle of the eyelids is probably due partly to an effort to expel the foreign body, as well as to protect against further injury.

In endothelial lined cavities or in solid tissue there is an attempt to wash away foreign irritating matter. This is done by the pouring out of serum from the lymph circulation in the neighborhood of the foreign substance, which is accomplished by the reversal of the circulation in the local lymphatics, so as to empty their contents around the irritating material. This is really the chief basis of surgical drainage.

In surgical drainage, mechanical measures that are followed by fortunate results would appear ridiculous if no biologic conditions existed. In preventing infection of a fresh raw surface, or in the so-called walling off of healthy tissue from the products of infection, gauze is often placed over the raw surface or as a coffer-dam in the abdominal cavity, and an abscess is drained through the center of this gauze packing. If we could convert this into a mechanical proposition and imagine that the pus was a solution of methylene blue and that it was flowing over this raw surface which had been covered with absorbent gauze to prevent contamination, we know that both the gauze and the wound would be deeply stained. This method of protection, however, does act in a beneficial

*This chapter is largely a reproduction of a previously published paper: Horsley, J. S.: Surgical Drainage from a Biologic Point of View, Jour. Am. Med. Assn., Jan. 17, 1920, lxxiv, 159-162.

manner, and a clean wound is often by this means kept from septic infection. The drainage of a peritoneal abscess is practically always up-hill and is usually successful. If mechanics were the only principle, how could an appendiceal abscess ever be drained by putting a tube down to it through the abdominal incision? The whole method of drainage really depends on the reversal of the circulation in the local lymphatics and is chiefly a biologic process. It is nature's effort to extrude a foreign substance.

A splinter in the finger which becomes mildly infected will provoke a discharge of thin seropus for days. This is nature's effort to expel the splinter. After it has been removed, the wound rapidly closes; and the lymph circulation, which was in part at least reversed in an effort to extrude the splinter, assumes its normal course, and probably in twenty-four hours after the splinter has been removed there is no further discharge.

The peritoneum and its underlying structures in the abdominal cavity constitute an enormous lymph space, and the lymph is here abundantly poured out in response to an irritation. The insertion of a drainage tube causes a reaction in which there is a flow of lymph in an effort to expel the drainage tube. Drainage of the abdominal cavity prevents positive pressure in the septic region, and also the drainage tube is a stimulus for a reversal of the lymphatic circulation. The packing of a fresh wound with gauze causes a similar reversal of the lymphatic circulation; and though pus may flow over this gauze from a deeper focus, the lymphatics, instead of absorbing the pus, pour out lymph into and around the gauze to extrude it. The beneficial action of the cigarette drain, which is soon clogged with coagulated lymph, is comprehensible when we look on it as a stimulus for reversal of the local lymphatic circulation.

In regions of the body in which the lymph supply is less abundant than it is in the abdomen, unless the infected focus is very small, it will be necessary to utilize gravity when instituting drainage, because there is not a sufficient flow of lymph to flush the septic cavity thoroughly and constantly, as there is with abdominal drainage.

Drainage in surgical operations may be classified under three heads:

CLASSIFICATION OF SURGICAL DRAINAGE

1. Drainage of solid tissue or endothelial lined cavities:
   - (a) Drainage of endothelial covered tissues of the abdominal cavity.
   - (b) Drainage of other endothelial lined cavities, as pleura, joints.
   - (c) Drainage of solid soft tissue, as muscle, fascia, fat.
   - (d) Drainage of bone.

2. Drainage of inflammatory products from infected epithelial lined hollow viscera, as the gall bladder and the urinary bladder.

3. Drainage of hollow viscera in order to restore function or to secure physiologic rest.

1. Drainage of Solid Tissue or Endothelial Lined Cavities

Considering first (1–a), drainage of abdominal abscesses, we find, as has already been stated, that the abdomen has an enormous supply of lymph and that the successful drainage of an abscess in this region consists, first, of relieving the pressure in the abscess cavity by opening it and inserting a drain; and, second, of inducing a sufficient reversal of the lymph circulation by the presence of the drainage material to cause much of the septic products to be washed away along the drainage track. If the drainage material reaches the abscess cavity so that the pus is not under positive pressure, and if the drainage is sufficient in amount and of the proper kind to act as a stimulus for reversal of the lymphatic circulation, so much lymph is poured out that practically a continuous irrigation is going on from the local lymphatics along the tube or track of the drainage material, and it is a matter of but little importance whether the drainage material is pointed up or down. But in other endothelial cavities (1–b), such as the pleura or the joints, where the lymphatic supply is much smaller than in the abdomen or where the configuration is such as to make the drainage difficult, gravity must aid and the problem becomes more mechanical than biologic. Drainage here should be at the lowest point possible.

Drainage carried down to sutured bowel frequently results in a fistula, particularly if gauze in the form of a cigaret drain is employed. The reversal of the lymphatic circulation in the neighborhood of a recently sutured intestinal wound, which will direct the current of lymph to the drainage, interferes with the normal process of repair in the intestinal wound, causes a weak fibrinous deposit, and diminishes the nutrition of the repairing bowel; consequently, the sutures readily break down and a fistula results.

In drainage of muscles, fascia and fat (1–c), gravity drainage must be considered, but the biologic problem is also prominent. An abscess in the thigh heals better if gravity drainage is instituted. The drainage material should be sufficient not only to carry off the secretion but also to excite the local lymphatics to reverse their circulation. The local lymphatics, being much less abundant than in the abdomen, cannot usually furnish enough lymph to cause the flushing out of the septic products, as occurs in the abdomen. In rapidly spreading inflammation, wide incisions and drainage are useful in relieving the pressure that is made by the binding fascia or skin, and in reversing the circulation of the lymphatics and so preventing absorption of much of the septic products into the main lymphatic trunks.

The old operation of "fence rail" incisions along the margin of an advancing erysipelas causes the pouring out of lymph from these cuts and the diversion of the lymph current, which would otherwise carry the septic products to further uninfected regions. The undermining of the skin and insertion of tubes or gauze drainage from point to point make the pouring out of lymph along the drainage material even greater than after a simple incision.

That the reversal of the circulation is the chief biologic process by which surgical drainage acts beneficially in solid soft tissue, can also be recognized when there is a small abscess in a large amount of inflammatory exudate and it

is impossible to locate the small abscess cavity. If a drain is placed in its immediate neighborhood the abscess frequently opens into the drain. It seems probable that this occurs because the lymphatic current attempts to extrude the drain and so the products of the abscess are carried in this direction, and the abscess burrows to the tube.

The drainage of tissues whose lymphatic trunks have been clogged and where, consequently, edema is present depends on an effort to increase the lymphatic circulation or to create new lymphatic connections. In the operation of Handley in which long threads of silk are placed under the skin in edema of the arm, lymphatic channels form along the threads. In the operation of Kondoleon, the deep fascia of the arm or leg is split in order to promote an anastomosis between the deep and the superficial sets of lymphatics and so to divert the lymph current from the superficial to the deep lymphatic trunks.

Local edemas that are persistent are usually caused by blockage of the lymphatic channels and not by interference with the blood circulation. The edema that sometimes appears in the arm after a radical operation for cancer of the breast in which the axilla is thoroughly dissected is due to the removal of the lymphatics. If this immediately follows operation, it may disappear when the collateral lymphatic circulation is established; but when a late edema results it is frequently because the lymphatics have become plugged with cancer cells; and such an edema is ominous. Resection of the axillary vein if the lymphatics are in satisfactory condition, is followed by but little if any swelling in the arm, and that of a temporary nature. A phlebitis causes edema only when the lymphatics around the vein are involved in the inflammation.

Drainage of wounds after radical operations for carcinoma in solid tissue should always be done. This is not so much in order to carry off the fluids that may accumulate in the wound, as an effort to reverse the circulation of the lymphatics which may be induced to pour out their contents in the direction of the drainage tube and so to discharge through this drainage cancer cells that have been left in the wound or that may have lodged in the open lymphatics. This is an important step in many radical operations for cancer, as after operations in the neck or on the mammary gland.

Drainage of bone (1–d) involves problems of a somewhat different nature, because of the structure of bone. Bone is compact, rigid tissue in which lime salts are arranged in an orderly way. On account of the rigid structure it is impossible for either blood vessels or lymphatics to form, or for the lymph current to reverse, as readily as in soft tissue. Before drainage can be accomplished or any effective stand against infection can be made, the lime salts must be removed, so converting bone into what is practically soft tissue. For this reason, in areas of inflammation bone is always soft. Around an irritating substance in bone, whether accompanied by infection or not, lime salts are absorbed. When this is accomplished the offending material becomes loose and is prepared for extrusion. If, for instance, a piece of iron, as a screw used in plating bone, is inserted into a bone, the lime salts in the neighborhood of the screw and of the plate are absorbed. The screws, which may have been very

tight and firm when inserted, gradually become loose. This induced osteoporosis around the screws and the metal plate is just the reverse of what is desired when a fracture is to be repaired, and it accounts for the frequency of nonunion after the plating of bones.

The numerous so-called abscesses at the roots of teeth are probably often the result of the reaction of the bone in the neighborhood to some material that was used in filling the cavities in the roots of the teeth. Undoubtedly apical abscesses frequently occur, but it is probably equally true that an osteoporosis sometimes interpreted as an apical abscess may be sterile and due to the reaction of the bone to the material with which the root of the tooth has been filled.

Because of the poor lymphatic supply of bone and its rigid walls which protect its vessels, a bone abscess may be more readily disinfected by means of strong antiseptics, such as phenol (carbolic acid), than if the abscess were in soft tissue. Here, as disinfection can be more thorough, the necessity for full drainage in the milder chronic infections of the bone is not so great, if the diseased bone has been removed, as it would be in soft tissue. Consequently, "fillings" or "bone plugs" are utilized.

2. Drainage of Inflammatory Products From Infected Epithelial Lined Hollow Viscera, As the Gall Bladder or the Urinary Bladder

Drainage here involves principles different from the drainage of an abscess that has formed in solid tissue. This drainage not only is for removing the products of infection, but serves a double purpose of also giving physiologic rest to the infected organ. The drainage of a septic gall bladder that may be filled with pus carries off the products of the bacteria and at the same time gives rest to the gall bladder by preventing distention, and this removes both a stimulus for contraction and the tension that would occur on the distended walls. Drainage of this type does not have to be gravity drainage. If a sufficient opening is provided in the general axis of the peristaltic current, it is all that is necessary. In draining an infected urinary bladder, for instance, an opening made at the top of the bladder is as satisfactory in securing results as an opening at the bottom.

When these hollow muscular organs are contracted, a small opening will insure the vicera keeping empty if it is made in due regard to the action of peristalsis. Even in such instances, however, the beneficial action of the drainage is not solely the removal of the contents of the hollow viscera or the giving of physiologic rest. It seems highly probable that reversal of the lymphatic current is also of importance here. This appears to be borne out by the results of drainage of the bile tracts in inflammation of the pancreas. It is well known that chronic pancreatitis can best be treated by prolonged drainage of the bile tracts; and drainage of the common bile duct for this affection seems to be particularly effective. The work of Deaver and Pfeif-

fer[1] on pancreatic and peripancreatic lymphangitis is interesting in this connection. They call attention to the anatomy of the lymphatic supply of of the pancreas and its ultimate connection with the lymphatic supply of the bile tracts and gall bladder. They say:

"To the objection that infection to be carried into the pancreas must stem the efferent lymph current and force the valves, the answer can be made that everyone has seen infection in cellular tissues proceed in a reverse direction to the lymph current. Thrombolymphangitis readily diverts the normal lymph course and infection easily destroys valves. The forces of pathology here as in so many other instances pervert the normal function."

If infection of the pancreas can be through the lymphatic supply from the gall bladder or the gall tracts, as Deaver and Pfeiffer assert, it seems that the method of relieving this infection is to reverse the lymphatic current and cause it to be diverted toward the drainage tube and the incision in the gall bladder or in the common duct, just as the lymph flow is reversed in the drainage of an abdominal abscess. Septic products that would be carried in the lymphatics from the infected gall bladder to the pancreas are thus diverted to the drainage tube in an effort to extrude it. If this diversion can be maintained sufficiently long to permit nature to build up the resistance of the pancreas to the infection and repair the damage already done, the patient may be considered cured. But if the drainage tube is removed too soon, there is no further stimulus for a reversal of the lymph circulation, and the pancreatitis recurs.

Too early resumption of function after drainage of inflamed hollow viscera frequently results in a recurrence of the inflammation. This may be due to one of three causes, or more probably to a combination of three causes: (1) There may be an accumulation of secretion that is not free from the products of the inflammatory process. (2) There is an interruption of physiologic rest. (3) There is a change in the lymph current from that which has been instituted by the drainage.

3. Drainage of Hollow Viscera for Physiologic Rest

In enterostomy, the operation may be done to side-track the normal contents of the hollow viscera and so to afford less work for the diseased tissue below the point of opening, as in colostomy for disease of the large bowel farther down. Drainage may be instituted to prevent distention of a hollow viscus and so induce rest in order that an operative wound may heal. This principle is put into practice in such operations on the bladder as for vesicovaginal fistula when a self-retaining catheter is placed in the urethra, and in the introduction of a tube through the rectum and through the site of resection of the sigmoid or left colon in order to draw off the gas and prevent distention in the region of the operation. This principle of

[1]Deaver, J. B., and Pfeiffer, D. B.: Pancreatic and Peripancreatic Lymphangitis, Ann. Surg., 1913, lviii, 151-163.

drainage is often utilized after the removal of stones from an uninfected gall bladder.

DRAINAGE MATERIAL

The material for drainage must be considered not only with regard to transporting the products that are to be drained, but also with regard to the biologic influence of the drain on the local lymphatics. Certain substances call for a more pronounced flow of lymph than others. Rubber, for instance, is not so irritating to tissue as gauze. When gauze is placed over a raw surface, the local lymphatics pour into the gauze quantities of lymph. This is Nature's effort to extrude an irritating foreign substance. When the lymph has coagulated, the meshes of the gauze become entangled with the wound and an effort to remove the gauze before this fibrin has softened results in tearing the delicate tissues of the wound and injures its granulations, causing bleeding. An ideal drainage material would be one which, on the one hand, is a pronounced stimulus for the lymph to be poured out along the drain, and, on the other hand, would not be sufficiently attached to the raw surface of the wound to injure it. This material has not yet been found.

Rubber drainage tubes are frequently used, and have the advantage of draining off inflammatory products readily; but they do not provoke such an outpouring of lymph as gauze would. Naturally, however, the larger the tube the greater the irritation, and the more pronounced the stimulus for a reversal of the circulation of the local lymphatics. Consequently, for draining an abdominal abscess, it is often found that a large tube does better than a smaller one, not because the smaller one is insufficient to carry off the serum or the pus, but because the small tube is not large enough to provoke a sufficient amount of reaction among the local lymphatics. Frequently the advantages of both gauze and rubber are combined by placing a gauze strip inside the tube or by wrapping strips of gauze in rubber tissue or rubber dam, which is called a "cigarette drain," and using this in addition to a tube. In this way the gauze which is exposed at the end of the cigarette drain causes a more pronounced flow of lymph than the rubber tube alone could produce, and the tube drains away the lymph that is thrown out to extrude the gauze and the tube. Drainage material should not remain too long in a wound, else it will act as the infected splinter mentioned above.

Combinations that are effective have been worked out to a large extent empirically. Sometimes strands of catgut, silkworm-gut, or strips of rubber tissue are inserted into a wound in which it is anticipated that there may be a collection of serum or broken down fat on account of the nature of the wound. This foreign substance, the drainage material, directs the current of the lymphatic flow toward itself and so prevents an accumulation in the tissues which might later become a culture medium for bacteria. An open superficial abscess often needs no drainage material, for the necrotic products of the inflammatory process are a sufficient stimulus for drainage.

ENCAPSULATED FOREIGN BODIES IN THE PERITONEUM

If such foreign materials as gauze or cork are left in the abdominal cavity under sterile conditions, they are rapidly surrounded by a deposit of fibrin, as shown by Hertzler.[2] This fibrin, which is coagulated lymph, soon is covered with endothelium and takes on the characteristics of peritoneum. If the gauze is left for a number of weeks or months, it may intrude into a neighboring hollow viscus and be expelled, as this may be the point of least resistance and, consequently, of greatest pressure. Instances are recorded in which gauze that has been accidentally left after a surgical operation has been expelled by the bowel or by the bladder months or years later. Sometimes, however, the gauze is completely encapsulated with a cystlike wall and becomes so thoroughly infiltrated with fibrin that partial organization takes place. Portions of the gauze may be disintegrated and removed by phagocytes, and the connective tissue penetrating the rest of the gauze is so intimate that it may have to be dissected away with much difficulty.

CRITICISMS

The phrase "reversal of the lymph circulation" may not have been happily chosen, but I know no other that would be quite as satisfactory. I fully appreciate the impossibility of any reversal of blood circulation and in other communications I have attempted to demonstrate that a vein and its contributing branches would not function as an artery when an arterial current is turned into the vein.[3] It was at one time, however, rather generally held that the blood circulation could be reversed in this manner.

The phrase "reversal of the lymph circulation" is not intended to mean reversal in the physiologic sense, that is, change in the direction of the lymph current within its normal channels. Surgical drainage is not a physiologic but a pathologic process. Lymph or serum is continually poured around an offending foreign body until the foreign body is removed. This lymph comes partly from the injured lymph channels and lymph spaces in the tissues and partly through the uninjured walls of the lymph channels which become more permeable with the hyperemia that is present when surgical drainage is necessary.

These are facts that are largely self-evident. The moot point is whether this process can be called reversal of the lymph circulation. This phrase was used because it seems to me that the current of lymph or serum continually poured out to the surface of the skin for days or weeks constitutes in a sense a circulation of lymph. This current, if it rises to the surface of the body and appears on the skin or mucous membrane, is not in the direction of any known lymph current and probably is a reversal, or at least a deflection, of the direction of the adjoining normal lymph currents. Then, too, this phrase seems to emphasize a phenomenon that many surgeons apparently ig-

[2]Hertzler, A. E.: The Peritoneum, St. Louis, 1919, C. V. Mosby Company. i, 251-253.
[3]Horsley and Whitehead: Jour. Am. Med. Assn., March 13, 1915, pp. 873-877; Horsley, J. S.: Ann. Surg., March, 1916, pp. 277-279.

nore. The phrase "outpouring of lymph" occurred to me but this suggests an almost instantaneous process, or at least one that covers a very short space of time.

It may also be objected that "lymph" is used in rather a loose sense. I have employed it as indicating the thin, clear fluid that is found in the lymph channels and spaces of the body and that infiltrates the tissues in edema. In order to describe the phenomena of surgical drainage it appears to be necessary to use the words "lymph" or "serum" to indicate such fluids.

CHAPTER III

TECHNIC, SUTURES, AND INSTRUMENTS

The technic of an operation refers to the mechanical steps of the procedure and also to the manner in which the operator and his assistants execute these steps. Before the institution of antiseptic surgery, and particularly before general anesthetics were introduced, the time consumed in performing the operation and the style in which the operator worked were considered extremely important. Naturally, with a suffering patient without an anesthetic it was highly important to complete the operation as soon as possible. It was also found in preanesthetic days that a quick operation was usually more successful than one that was prolonged. In order to operate as quickly as possible, certain movements, methods of holding the knife, and of securing vessels, were considered good form, without which the proper speed could not be obtained. This is similar to athletic games, as in tennis, golf or base ball, where the tennis racket, golf stick, or bat must be held in such a position or swung in a certain manner in order to secure the approval of experts on form.

When the surgeon made a practice of washing his hands only after the operation and when instruments, hands and everything that came in contact with the wound, were loaded with bacteria, naturally the quicker the operation was done the better it would be for the patient, because the longer the wound was exposed to the septic hands of the surgeon or to the infected instruments or sponges, the greater would be the infection. Quick surgery in such instances was justly considered a vital necessity. There is not the same demand, however, for speed since the development of anesthetics and aseptic surgery. It is infinitely more important to do a clean operation gently than it is to do a rough operation quickly. The operation should be completed, however, as soon as is consistent with thoroughness, gentleness and the complete application of the principles of aseptic surgery.

The instruments used should, of course, be such as may be needed in the performance of an operation, but effort should be made to use no more instruments than are necessary. Special instruments always carry the necessity of proving their worth. If an operation can be satisfactorily done with a sharp knife and sharp scissors and careful manipulations, there is no real need for special instruments, even though some surgeons require them. It is essential to have instruments that are reliable and of good quality. It is not only provoking to the surgeon to have a dull knife and dull scissors, but it is unfortunate for the patient. In dissections, particularly around large vessels, dull instruments are dangerous, because undue effort has to be made

with dull instruments to divide tissues where merely a gentle stroke of a sharp knife is all that is necessary. Consequently, the force and direction of the cut with a dull knife or scissors cannot always be as accurately gaged as with a sharp instrument. At one time it was fashionable to have forceps and scissors constructed with so-called aseptic locks, so they could be taken apart easily and cleaned. Such instruments frequently fell apart while they were being used and the joints soon permitted such play as to make the instruments useless. Forceps and scissors can be joined by screw locks and cleaned and thoroughly sterilized by boiling.

Suture or ligature materials are used in almost every operation. There is great difference of opinion as to choice of suture material and much is left to the individual surgeon's judgment. The sutures usually employed are silk, silkworm-gut, horsehair, linen, catgut, kangaroo tendons, silver wire, and bronze wire. There are certain operations in which there is almost unanimity of opinion among surgeons as to the type of suture material to be used. In most instances, however, the difference of choice is marked. Many operators use catgut for almost everything. The former objection to catgut, that it could not be properly sterilized, hardly exists to-day. It is true that sterilization of catgut is more difficult than sterilization of the nonabsorbable suture materials which may be boiled. By elaborate processes and repeated sterilization, however, catgut can be made entirely safe from the standpoint of sterility. Its rate of absorption can also be regulated to some extent by the size of the strand used, but particularly by impregnating the catgut with chemicals that make it resist absorption. The two most used of these are chromic acid products and tannin. They are also used in curing leather. By regulating the strength of the solution of these chemicals and the time during which the catgut is exposed to the solutions varying rates of absorbability are produced. These rates, however, are not entirely accurate. The chief objection to catgut these days is that it is irritating to the tissues, particularly when impregnated with iodine, and causes more reaction than do nonabsorbable sutures. If the catgut is not impregnated with some antiseptic it soon becomes a culture medium, and if the wound has been contaminated or if there is a hematogenous infection the catgut may become the center of suppuration. When catgut is used in the mucosa of the gastrointestinal tract, it is, of course, rapidly absorbed, but if it is buried by successive layers, properly selected and applied, it will hold a sufficient length of time for union to take place. It has an advantage in operations upon the stomach, in that it is in the course of time completely absorbed if not too strongly tanned or chromicized, whereas if silk or linen are used they are extruded toward the lumen of the stomach and sometimes become entangled in the mucosa and form a source of infection and continued irritation. In the vaginal mucous membrane catgut is not absorbed so quickly as in the gastrointestinal tract, but much more rapidly than in skin or muscle.

Nonabsorbable sutures when buried often give trouble. It is not uncommon to find sinuses that occur months after operations, when buried non-

absorbable sutures are used and these sinuses will not heal until the sutures are removed. In buried sutures, particularly in operations for hernia, it has become the custom to use absorbable sutures, tanned or chromic catgut or kangaroo tendons. If nonabsorbable sutures are employed the smallest strands that can safely be used should be chosen. The larger the bulk of material the more the likelihood of trouble and sinus formation. When very fine silk is used to tie vessels and the aseptic technic is perfect, no trouble may result from the nonabsorbable suture, and in time such fine strands are absorbed or encapsulated. The majority of surgeons, however, find that for all buried sutures or ligatures absorbable material is, in the end, more satisfactory.

In plastic work, catgut is not the ideal suture material. Its tendency to cause considerable reaction during the healing of tissues makes more exudate and frequently results in a more conspicuous scar than is obtained when nonabsorbable material, such as fine silkworm-gut, silk, or horsehair is used. There is not the same excuse for using catgut on the surface of the wound, where it can be easily removed, as when a suture or ligature must be buried. Fine plastic work on the skin, where an inconspicuous scar is desired, calls for nonabsorbable sutures.

When catgut is used in buried sutures the smallest strand that will do the work should always be selected. For ligating most bleeding points, 00 plain catgut is sufficient. It must be remembered that catgut is absorbed and the larger the strand the greater the burden of absorption placed upon the tissue. In addition to this, a fine strand of any material holds the knot better than a coarse strand. There is less likelihood of the knot slipping in a fine strand because there is more friction, due to greater surface compared with cubical contents in the smaller strand. It is better to use two fine strands of catgut than one large one because they can be more readily absorbed. It is important in all sutures not to tie the knot too tightly so as to constrict tissues unduly. This is particularly true of catgut.

Besides plastic work, special suture material is indicated in special regions. Marion Sims' well-known experiments showed that silver wire was the only material with which he could satisfactorily repair a vesicovaginal fistula. This is not only because it can be handled easily, and nicely adjusted, but because metallic silver itself is mildly antiseptic and has no capillary action. Improved aseptic methods permit other suturing material to be used in repairing these fistulas but the lesson taught by Sims is frequently neglected. Fine silver wire, 28 or 30, is exceedingly useful in cleft palate operations.

For bone, stouter suturing material must be used. Some have recommended heavy kangaroo tendon, but with the mechanical friction with sharp edges of bone these tendons may not hold long enough. Moderately stout wire, particularly a cable of fine bronze wire, is especially suited for work

on bone, though where the strain is not great, tendon or tanned catgut is satisfactory.

When through-and-through sutures are used in the abdomen nonabsorbable sutures should always be employed. Silkworm-gut is excellent here, though stout silver wire is used by many surgeons and has the advantage of being mildly antiseptic.

For suture material in the intestines, I prefer linen or silk, though some surgeons use catgut. The nonabsorbable suture seems to be extruded into the lumen of the intestine and rarely, if ever, causes trouble. If a single line of sutures is used in operations upon the intestine and catgut is employed it may be absorbed too soon and perforation result. This is because in order to secure a firm hold in intestinal suturing it is necessary to catch the submucous coat or to penetrate into the lumen of the intestine. Where the suture

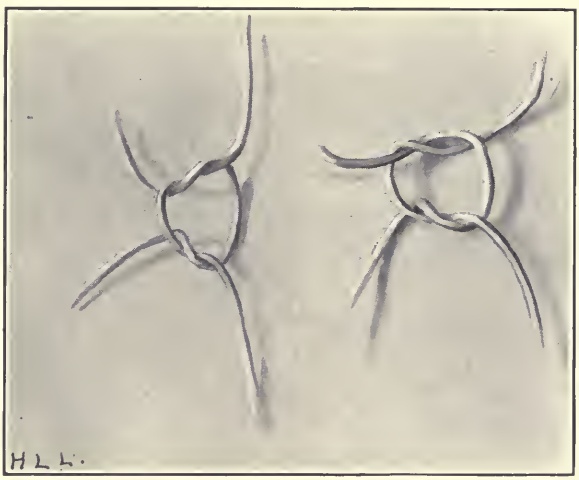

Fig. 1.—Reef or flat knot. Fig. 2.—"Granny" knot.

penetrates into the lumen the rate of absorption of catgut would be so rapid as probably to be unsafe unless the catgut was tanned or chromicized to such an extent as to make it practically a nonabsorbable suture.

When a suture material is used as a drain for a long period of time, as in turning a salivary fistula of the parotid into the mouth, silver wire should always be the choice because it is not only easily handled, but its antiseptic properties tend to keep the wound clean.

The thick walls of the stomach permit the use of catgut when there are several layers of sutures and when at least one of these layers is not in contact with the mucosa.

One of the most important procedures in the technic of surgery is tying knots. This can be done by any method that the operator finds best suited to his individual requirements (Figs. 1 and 2.). The all important point, as taught by the old authorities, of making every knot a reef or flat knot has

been greatly exaggerated, but undoubtedly a reef knot does hold better than the "granny knot." The surgeon's knot consists of a double turn in the first tie and a single turn in the second. The double turn in the first tie secures the thread so that the second tie can be run down without the first slipping. The fallacy in this, however, is that when two wraps or turns are made instead of one it is more difficult to run the first tie down smoothly and it is hard to tell how much pressure is being made on the tissues and how much is being taken up by the extra friction of the double wrap. As Royster says of the surgeon's knot: "the surgeon's knot is a knot that the surgeon does not use." In order to secure accuracy in tying large vessels or in mass ligatures, it is much better to make merely a single wrap as in the reef knot and while this is tight have it held firmly with a mosquito hemostatic forceps, which is strong enough to prevent the tie from slipping and at the same time is not strong enough to injure the thread. The second tie can then be run down easily. In any important suture or ligature it is best to make three ties to the knot instead of two. Then the knot will hold whether it is a "granny" or a reef knot.

In making a knot it is well to cultivate the art of tying it with one hand, as it frequently saves time and suture material. The finer the strand used for suture or ligature the more likely the knot is to hold, because there is more friction, as the surface of the fine strand is greater in proportion to its cubical contents than in the coarser strand.

The reef knot lies flat because the loop on each side is over both strands of the thread. The tying of the reef knot can be best accomplished by concentrating the attention on one end of the thread and disregarding the other. If the first tie of the knot is so made that the right end lies away from the operator, the same end should then loop over the left end in the second tie in such a manner that it crosses the left end from above downward and towards the operator, and then passes through beneath the loop made by the left end. If this can be borne in mind a flat or reef knot will always result, but even then, it might be wise to make a third tie.

A. R. Grant, of Utica, N. Y., has described an excellent method of rapidly tying a knot with forceps so that the thread need not be touched with the hands and with great saving of suture material.[1] If the operator wears good rubber gloves there is no objection, from the standpoint of asepsis, to tying the knot with the hands, but not infrequently when there is a short end it can be tied more accurately and more quickly by this method of Grant than with the fingers. It is also useful for tying in deep cavities where the fingers or hands cannot readily reach (Figs. 3, 4, 5, 6, 7, 8, 9 and 10). The technic as described by Grant is as follows:

If the knot is to be tied in a transfixion suture or ligature, first transfix the tissues with the needle, which must be pulled through with forceps, and catch the suture near the needle with forceps in the left hand. Pull on the

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[1]Ann. Surg., April, 1918, p. 439.

thread until the right hand short end is only about one-half inch long. The long end should be proximal and the short end distal to the operator. Lay the point of the needle holder across and on top of the suture just below the point where the suture is being held with thumb forceps pointing upward toward the tip of the thumb forceps, and make a loop as shown in the

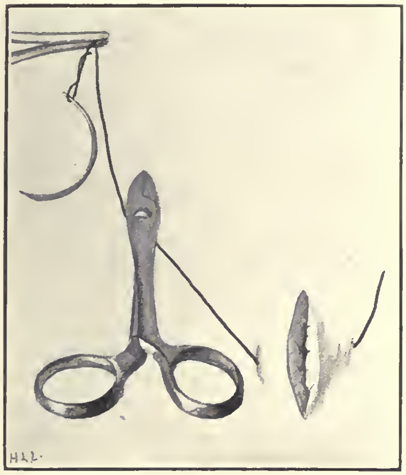

Fig. 3.—Grant's method of tying knot with forceps. The suture has been passed and forceps laid to the right of the thread.

Fig. 4.—Forceps have made a loop in the thread, with the nose of the forceps up.

Fig. 5.—The tip of the thread is grasped with forceps.

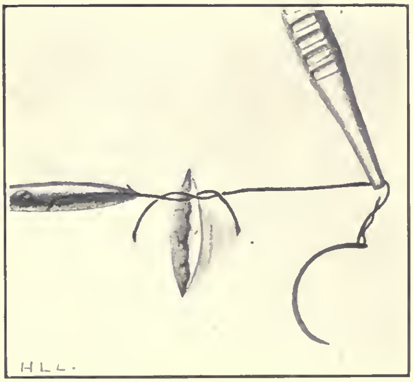

Fig. 6.—The thread is pulled through, forming the first tie of the knot.

illustration. Then catch the short end of the suture with the tip of the needle holder and pull the short end through the loop while the left hand holds the long end of the suture taut with the thumb forceps. Next place the needle holder *beneath* the suture and make a second loop, catching the short end as before. This always results in a reef or flat knot.

Knots can be tied quickly in this way, with short ends and with a minimum amount of material. They can also be made in cavities in which it is difficult or impossible to use the hand or fingers.

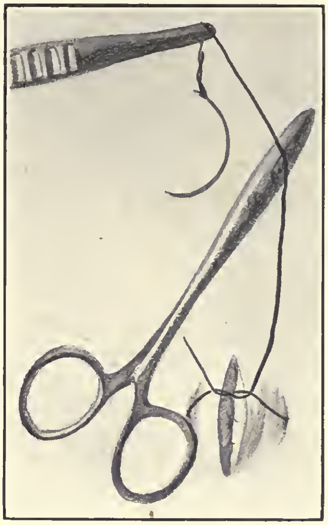

Fig. 7.—The second loop is made with forceps, this time with the forceps to the left on the under side of the thread.

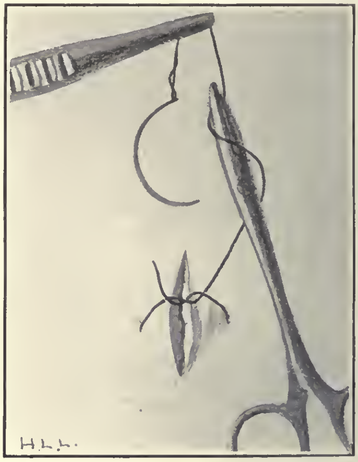

Fig. 8.—The loop has been completed.

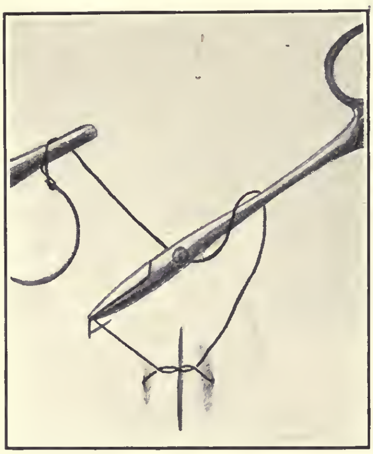

Fig. 9.—The tip of the thread is drawn through.

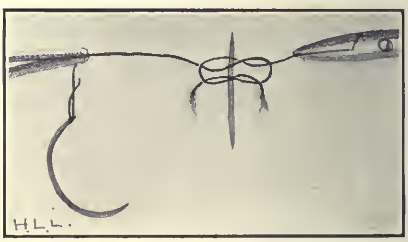

Fig. 10.—The second tie of the knot is completed, making a reef knot.

CHAPTER IV

COMPLICATIONS OF OPERATIONS; INFECTION, SHOCK AND HEMORRHAGE

Infection, shock and hemorrhage, while different entities, are not infrequently associated. Hemorrhage during an extensive operation often results in shock, and if the patient's resistance is lowered by hemorrhage and shock, infection is likely to occur. All three of these undesirable complications can, in the vast majority of cases, be guarded against by a proper consideration of the operative procedure before it is begun and by its careful execution. Infection, of course, is wrapped up with the history of antiseptic and aseptic surgery, which was begun by Lord Lister in the seventies, and has gradually developed through a series of stages to the present technic. While the present technic is a great improvement over what has gone before, it cannot be considered ideal.

If infection follows an operation on previously uninfected tissues it should be a source of deep concern to the surgeon and his associates. While it is true that in a large series of cases a small percentage of infection will occur even under the best conditions, this is no excuse for a careless regard of those infections that do take place. Still less should it be an excuse in other hands for a larger percentage of infections.

It is impossible to have an iron-bound technic for every surgeon, but there are certain principles which he should follow if his work is to be reasonably free from sepsis. The consideration of the patient, his general condition, the presence of sore throat, or a focus of infection elsewhere or the prevalence of an epidemic, such as influenza, should be carefully considered before deciding upon operation. During epidemics of influenza many surgical disasters have occurred by operating upon patients who were at the time of operation apparently free from influenza, but who had a slight sore throat. In the reports[1] of streptococcic infection at Camp Custer, Mich., a number of cases are cited in which operations that were done with apparently perfect aseptic technic resulted in infection and other instances occurred in which even after the wound had almost healed a streptococcic infection, usually by the streptococcus hemolyticus, occurred. This was thought to be a hematogenous infection and in every case cultures from the throat showed the same type of streptococcus that infected the wound. To operate upon a cleft palate, for instance, in the presence of a sore throat or bad teeth is surely inviting infection to the wound. The environment of the operation and patient must be considered. Dust infection has been regarded too lightly in recent years,

[1]Blanton, Burhans and Hunter: Jour. Am. Med. Assn., May 24, 1919, lxxii, 1520-1524.

and more effort should be made to avoid it. The location of the operating room with regard to drafts of air is important. The operating room should be on the top floor of the hospital and as isolated as possible from the rest of the hospital. It should, of course, be so furnished and equipped that it can be readily cleaned, and while it should be comfortable, asepsis must not be sacrificed for comfort. A chandelier that hangs over the wound is always a potential source of dust infection. It is difficult to clean and the least touch or jar is likely to send down myriads of particles of dust into the wound beneath. The artificial lighting of the operating room should preferably be on cranes that can be swung out of the way during the day time.

With some surgeons it is a practice that the fingers even when incased in sterile rubber gloves should never touch the wound. That a wound should not be unnecessarily handled with the fingers and that bone should be manipulated chiefly, if not entirely, with instruments is obvious; but the resistance of the tissues of the patient must always be kept in mind and gentle fingers in sterile rubber gloves will do less damage to tissues and so conserve the patient's natural defenses to a greater extent than bruising and crushing with steel forceps. If a rubber glove has no holes and has been boiled it is just as sterile, if there be degrees in sterility, as any steel instrument can be. Every time tissues are unnecessarily mashed or squeezed there is an added burden placed upon the tissues in making repair and the slightest infection from air or elsewhere will find a ready culture medium.

The margins of the skin or mucous membrane are prolific sources of mild infection. It is always best to cut through the skin or mucous membrane with a knife and then lay it aside, because it is impossible to sterilize the deep layers of the skin by any process that will not destroy the skin. If the edges of the skin or mucous membrane are caught with hemostatic forceps or bruised by handling with heavy thumb forceps, not only is tissue injured thereby, but the staphylococcus albus, whose normal habitat is in the hair follicles and sweat and sebaceous glands, may be squeezed into the wound and cause an infection, or at least retard healing (Fig. 11.). This is probably one cause of the so-called stitch infection. While the staphylococcus albus is the normal inhabitant of hair follicles and sebaceous and sweat glands, if injured tissue is inoculated by these germs, infection may ensue just as infection occurs from the colon bacillus whose normal habitat is the colon.

In bone operations it is best to handle the bone as far as possible with metal instruments because bone can be so manipulated without injuring it and for the further reason that the sharp spicules of bone are likely to puncture the rubber glove of the operator. In soft tissues, however, if the operator is sure of his gloves and handling of the wound must be done, it is much better to do it with a gloved hand than with steel instruments. It is doubtful if any operative wound can be considered free from bacteria if the operation lasts an hour. If no virulent pathogenic bacteria have been introduced during the operation and if the wound has been handled gently and without too much damage, the few germs that do gain access to the wound can

ordinarily be taken care of by the natural defenses of the tissue. A large petri dish containing a sterile culture medium, exposed on the instrument table during the time of operation and covered and cultured later, will almost invariably show a few colonies of bacteria. If these have dropped from the air into this culture medium, it is at least probable that the wound has received the same infection. This makes it all the more important not only

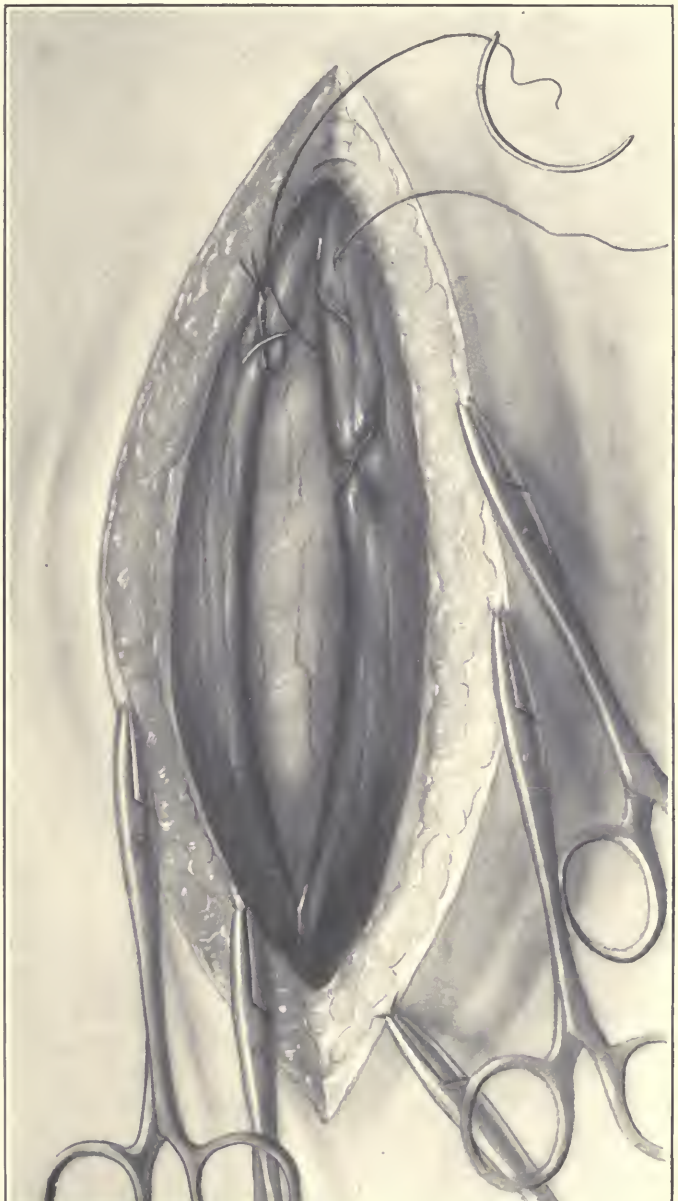

Fig. 11.—Control of hemorrhage in abdominal incision by whipping over the muscle with catgut. This drawing also shows method of catching vessels without including the skin in the bite of the forceps.

to conduct the operation according to a sterile technic, but to preserve by gentle work the natural defenses of the tissues.

The fad of not touching the wound with the gloved hand sometimes becomes almost absurd. I have seen moving pictures of a hernia operation done by a surgeon who claims that the fingers should never touch the wound because of their liability to carry infection. The literal part of the technic, so far as the operator was concerned, was well carried out, and yet the screen showed that the blood vessels that had been carefully grasped with forceps were tied with catgut applied by the fingers of the assistant who was probably an intern, and we know that the intern is often the "goat" for cases that become infected after operation.

In intestinal suturing often no attempt is made to sterilize the mucosa of the incised intestine. This is probably not essential in stomach surgery or in the duodenum or upper jejunum, as but few pathologic bacteria are found in this region, but the ileum and the colon teem with bacteria of infection and it seems just as essential to clean the ends of the bowel which are to be united and mop them with some antiseptic solution as it is to clean a dirty skin before incising it. An intestinal suture to be safe must penetrate into the lumen of the bowel. If no effort is made to disinfect that lumen the needle and thread become very common carriers of germs and smear bacteria wherever they touch. There are other important details of avoiding infection in intestinal suturing, which will be considered in Chapter XXVI on Intestinal Surgery.

After every infection in a clean wound the surgeon and his operating staff should go over the case carefully, have a bacteriologic examination made of the pus and make an honest effort to fix the responsibility for the infection. While it is natural to expect that errors of technic come chiefly from inexperienced assistants and nurses, the operator should by no means consider himself infallible and if he is unwilling to take the blame when he is obviously at fault, the investigation will be more harmful than beneficial.

Shock, except in traumatic surgery, is rarely seen in the modern operating room. In some cases where the operative risks are great and the patient's condition will not permit of delay, shock may occur. Every surgeon with sufficiently extensive experience will sometimes encounter cases in which unexpected things happen during an operation, or in which the patient reacts in an unaccountable manner, and may be faced with unexpected shock.

The etiology of shock has caused much discussion, especially in the last few years. Crile holds that it is due to nocuous impulses that travel over the afferent nerves to the brain and are initiated by the trauma of the operation or injury. It is undoubtedly true that certain reflexes occur after nerve trauma with great promptness. Injuries to the testicle or blows in the epigastrium or manipulation of the mucosa of the larynx may be followed by collapse, or by greatly impaired heart action, or even by death. This, too, may occur where there is but little if any evidence of an organic lesion. This type of collapse seems somewhat different from the picture of shock.

The reports of the committee of medical research during the World War seem to indicate, as has been claimed by Cannon, that traumatic shock is due to the absorption of the products of traumatized tissue. Cannon has written interesting papers on this subject. Whether we hold with Crile on the nervous theory of traumatic shock, or with Cannon that it is a traumatic toxemia, it is equally true that gentle surgery is always demanded to prevent shock or to reduce it to a minimum. In this way the nocuous nerve impulses, as claimed by Crile, would be lessened; or if we hold to the traumatic toxemia theory of shock, gentle surgery would produce a much smaller amount of this toxic material than would rough surgery.

Certain individuals are more likely to be shocked than others. They seem to react more readily to the causes of shock. Conditions that may produce profound shock in some patients may cause but little disturbance in others. This, of course, is no excuse for neglecting precautions, but on the other hand should make us more guarded because of the inability to tell just how any given patient will react to a certain trauma.

Keith[2] has called attention to the great prognostic value of hemoglobin estimations in shock. He says that when dilution is taking place satisfactorily the hemoglobin falls, but if the fluid is not retained in the vascular system the percentage of hemoglobin decreases but little if any, and may even rise. If the hemoglobin rises the prognosis is exceedingly serious because it shows that the capillaries and small blood vessels are leaking to such an extent that the corpuscles of the blood are becoming concentrated within the blood vessels. After a few days, if dilution has taken place and hemoglobin percentage has dropped to 30 or 40, transfusion of blood may become essential, particularly if a surgical operation has to be performed, for such patients are prone to develop shock a second time if the hemoglobin is low. When operation must be done in the presence of shock or when the occurrence of shock is probable, nitrous oxide and oxygen anesthesia should be the anesthetic of choice. This anesthetic is less likely to produce shock than any other general anesthetic.

It has been found that acidosis is present in shock and at one time it was thought that great results could be accomplished by treatment along this line. Acidosis in shock, however, is probably a terminal, or at least a late condition, and while administration of bicarbonate of soda is indicated it should be only one of the measures used. The patient should be kept quiet and warm and should be well under the influence of morphine. Mangled tissue, if in a limb, should be excised gently and as quickly as possible. If there has also been loss of blood an abundance of water should be given by mouth, soda and glucose solution by enemas, or, if the need is more urgent, hypodermoclysis of Locke's solution should be administered. If this does not result in improvement of the patient's condition, transfusion of blood should be done.

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[2]Keith, N. M.: Report of a Special Investigation Committee on Surgical Shock, Special Report, Series No. 26, London, 1919, p. 43.

It must be remembered that in shock the fluid of the blood seems to accumulate in and around the capillaries and that the patient suffers from lack of circulating blood just as much as after hemorrhage. The difference, however, is that on account of this tendency for the capillaries to leak unduly, fluid in a badly shocked patient remains but a short time in the circulating vascular system.

Hemorrhage and shock are often closely allied, and the trinity of hemorrhage, shock and infection is a formidable combination. For years, Halsted, of Baltimore, has demonstrated that great care in preventing loss of blood during a surgical operation is almost a preventive of shock even when the operation is prolonged. Bleeding points should be carefully caught and wherever possible hemostasis should be complete before any operation has been concluded (Fig. 11). In some operations it is impossible to clamp and tie each vessel, as in operations on the prostate, but in such instances firm packing or some definite pressure sufficient to check the bleeding should be provided.

Where a large vessel is accidently injured during an operation, if it is a vein it can readily be controlled by pressure. If the vessel has been injured in only one place pressure should be made with a small piece of gauze or, better still, with the finger. This should be gradually withdrawn until the bleeding point is accurately located and clamped. It is then secured by a ligature, preferably in a needle. If the bleeding is venous and is sudden and overwhelming, a large piece of gauze or a towel should be immediately pressed into the wound and held until the bleeding has been somewhat checked. It is then gradually withdrawn until the source of the hemorrhage is exposed. If the hemorrhage comes from a large artery such pressure will be ineffective and the vessel can best be sought for and grasped with the fingers until the field is cleared and a clamp applied. This is better than the blind application of a clamp.

W. J. Mayo speaks of several instances in which the renal artery had retracted from the pedicle after nephrectomy or was injured during the operation and he promptly controlled the hemorrhage by first grasping the artery with his fingers and then clamping it. In such a large vessel pulsations can be easily felt and, as Mayo says, the "artery fairly jumps into the fingers", whereas the blind application of forceps in a bloody field may do great damage. After the vessel has been caught with the fingers, forceps can be accurately applied, and the artery ligated.

In hemorrhage from operations on the extremities, pressure should be made over the femoral or the brachial artery, or a tourniquet applied, but the tourniquet should be kept in place no longer than is necessary to control the bleeding vessel. Small points of bleeding should, when possible, be whipped over with sutures, preferably of catgut.

In abdominal operations, as after separating pus tubes, often a large area is left where the blood seems to ooze from every pore. The area sometimes is so great that it is difficult or impossible to control it with suturing and to suture blindly in the pelvis is fraught with danger. Packing, if abundant

and left too long, may be followed by many complications. In such instances, firm pressure with dry gauze on the bleeding area should be kept up for about five minutes; that is, for a little longer than the physiologic time for the blood to clot. Then the gauze can be gradually removed. Frequently the bleeding will have been entirely checked, or at least will be reduced to a few points that can be easily and safely controlled by suture or ligature.

Peroxide of hydrogen tends to oxidize and break up the blood corpuscles and particularly the platelets. Before making pressure an application of a small amount of peroxide of hydrogen will cause a rapid disintegration of the platelets and blood corpuscles and so provide an abundance of fibrin ferment to promote clotting.

There are on the market several preparations for promoting clotting, some of them containing fibrin ferment or its elements, and others the extracts of various tissues. Peroxide of hydrogen provides what might be called an autogenous fibrin ferment in abundance and is preferable to the manufactured products.

Variations of posture aid greatly in the control of hemorrhage in operations on the head. The head and the whole body may be elevated to lessen bleeding from the head and when operating upon a limb advantage may be taken of changing the posture if the application of a tourniquet is considered inadvisable. Bleeding is greatly lessened by elevating a limb. Whereever possible the application of a tourniquet should be avoided except in amputations or in regions of the limb that are unusually vascular. In patients of low resistance a tourniquet, which completely deprives the tissues of blood for a period of an hour or more, is a serious handicap in the healing of the wound and if a careful dissection with clamping of the individual vessels can be done, the eventual results will be much better.

Bleeding from bone, as in operations on the skull, may be controlled by the application of bone wax. This consists of bee's wax, 7 parts; almond oil, 1 part; salicylic acid, 1 part. This wax is antiseptic and absorbable and can be pressed firmly into the bone, so plugging up the bleeding sinus.

In operations upon the head and neck, Dawbarn formerly advised what he termed "sequestration anemia." He applied a tourniquet on all of the extremities close to the body, just tight enough partially to obstruct the venous return but not to occlude the arteries. Thus a passive congestion of the extremities is produced and a sufficient amount of blood is supposed to be dammed back in the extremities to lower the general blood pressure and consequently decrease the bleeding in the operative field. This, however, is a dangerous practice. The blood pressure is undoubtedly lowered by this procedure, but is not readily restored by removing the tourniquet. In several instances in which I operated upon the gasserian ganglion, this sequestration anemia was practiced, and toward the end of the operation the patient was in a mild state of shock from which he did not recover for several hours after the operation. I abandoned the practice and found that the patients did much better. The explanation of the mild shock caused in these cases is furnished

by the excellent experimental work of Frank Mann, of the Mayo clinic, who showed that deep shock can be produced in animals by obstructing the venous return from a limb while the artery is left open.

The liability of hemorrhage to emerge into shock must always be borne in mind. The two conditions are clinically very much alike, but often much light is thrown upon the situation by a careful blood count, as in shock without hemorrhage the red cells and the hemoglobin are not lowered.

The operator should learn that he can control any hemorrhage in the vast majority of cases by keeping cool and using common sense. In any sudden hemorrhage that comes from one point the fingers are the best temporary means of controlling the bleeding. If the bleeding comes from several points, packing is placed and gradually removed while the various points are grasped, or if this is impossible the packing may be left for a little time until most of the points have ceased bleeding. Tampons for permanent control of hemorrhage should rarely be employed, particularly if the bleeding is arterial.

In marked hemorrhage it sometimes becomes a nice point to decide whether general treatment, such as stimulation or intravenous injection of Locke's solution or salt solution should be used. If the blood pressure goes too low and impairs the nutrition of the vital brain cells recovery is impossible. If, on the other hand, the patient is stimulated too much, there may be a tendency for the hemorrhage to continue because of the increased pressure in the bleeding vessels.

The constitutional treatment consists in keeping the patient's head down in an attempt to adjust the blood pressure so it will not be too low for the brain. But the pressure must not be so high as to encourage the bleeding. In hemorrhage the immediate effect is from the loss of volume of blood, and hypodermoclysis of salt solution or, better, of Locke's solution, can readily restore this. If there is urgency, a vein may be opened and these solutions given intravenously. If the volume of blood lost is great, transfusion of blood should be done. Too much dependence must not be placed upon the percentage of hemoglobin following a sudden hemorrhage. Sometimes this percentage is abnormally high because with the low pressure and contracted vessels enough serum has not been absorbed to dilute the red corpuscles and it may be several hours or longer before the hemoglobin reaches a very low point. The best index for transfusion after a sudden severe hemorrhage during an operation when the patient does not react to Locke's or salt solution, is the clinical condition of the patient. It must be borne in mind that too great a depression from hemorrhage may result in shock and also will invite infection even if the patient's life is saved.

CHAPTER V

TRANSFUSION OF BLOOD

The technic of transfusion of blood has undergone many changes in the last few years, particularly since the citrate method of Lewisohn has become popular. The operation of transfusion of blood is an old one, though it has been used in a practical way, only within the last twenty years. The ideal method of transfusing blood, would be to transport it directly from the vascular system of the donor to the blood vessels of the patient over the vascular endothelium without break. This can be accomplished by uniting the two vascular systems. The objections to this method are the difficulty of the technic, the inability to measure the dosage accurately, and the liability of the heart of the patient to dilate if subjected to too much pressure from the direct arterial flow of the donor.

Transfusion of blood may be classified as: (1) Direct, in which the endothelium of the vascular system of the donor is directly united to or is in contact with the endothelium of the vascular system of the patient. (2) Semidirect, in which the vascular system of the donor is connected to the vascular system of the patient by a tube of some material and in which there is a break in the continuity of the vascular endothelium. (3) Indirect, in which the blood of the donor is drained into a receptacle or syringe and then transferred to the patient, either with or without chemicals to prevent coagulation.

Whatever method of transfusion is used it is essential, except in the gravest emergency, to secure a donor whose blood will be congenial with that of the patient. The division by Moss of all human beings into four different classes so far as the reactions of the blood and serum are concerned, has been generally accepted. The tests for hemolysis, and particularly for agglutination, should be carefully made. With recently improved laboratory technic this can be completed in a few minutes instead of taking a great many hours as was formerly done. The blood of the patient and the blood of the donor are matched or tested by standardized serum and assigned to one of four groups. There are cases of great urgency, however, in which even this short time cannot be spared. In such instances a donor who is preferably a blood relative or, if not, who is of the same race, should be selected. Care should be taken, of course, to eliminate the presence of such diseases as syphilis or any acute infection in the donor. His hemoglobin and red and white cell count should be recorded as well as his blood pressure, in order to check the changes that may occur during or after the transfusion.

The *direct method* is best represented by suturing the artery of the donor

to the vein of the patient. This can be done by the technic of Carrel or by my technic, which is described in Chapter VI on Suturing Blood Vessels. It is best so to select the vein of the patient that the site of union of the vein will be a short distance from a small branch of the vein. In this way the small branch can be clamped with mosquito forceps and if there is obstruction at the site of anastomosis a smooth probe anointed with vaseline is introduced through the small branch, passed up through the sutured vessels, and so can loosen any obstruction. By compressing the main trunk of the vein

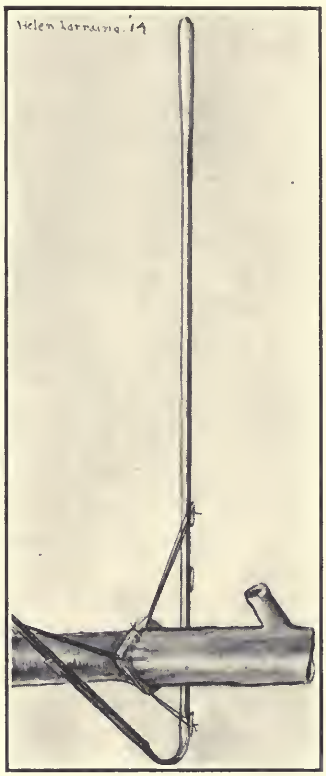

Fig. 12.—The author's method of transfusion of blood with the arterial suture staff.

just proximal to the small branch, the obstructing substance is forced out through this branch and the branch is again clamped. The compression on the main trunk is then removed and the current of blood permitted to resume its flow into the venous system of the patient. This method, while it requires time and experience in the technic of blood vessel suturing, is very satisfactory (Fig. 12). The flow should be permitted to continue until the hemoglobin or the general condition of the patient seems sufficiently improved or until the condition of the donor shows that as much blood has been withdrawn as is compatible with his safety. If the flow is occasionally interrupted or greatly diminished by compressing the artery with the thumb and finger, there will be less likelihood of dilatation of the heart and the

donor will stand the loss of blood better than if the full flow of the artery is continued without intermission.

The direct method can also be employed with the cannula of Crile or some of its modifications. This cannula which is modeled on the tube of Payr, has been variously modified (Figs. 13, 14, 15, 16 and 17). Hepburn has introduced a modification in which there is a collar with four perforations

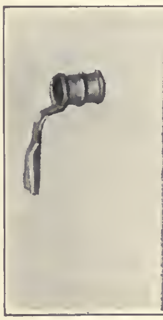

Fig. 13.

Fig. 13.—Crile's cannula for transfusion.

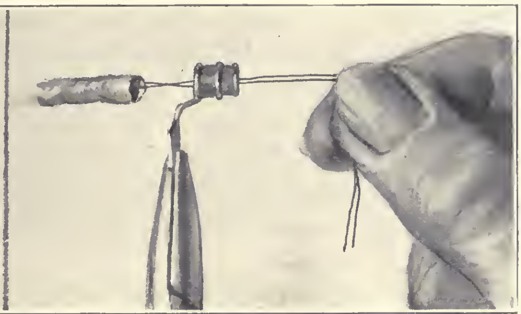

Fig. 14.

Fig. 14.—The vein is drawn through the cannula with a fine suture.

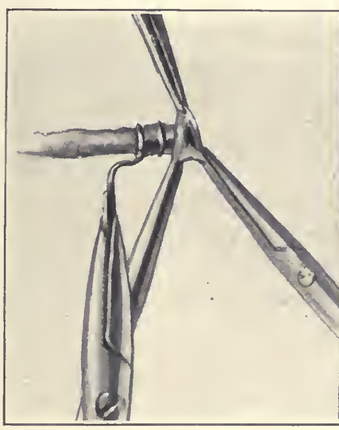

Fig. 15.

Fig. 15.—The vein is cuffed back over the cannula.

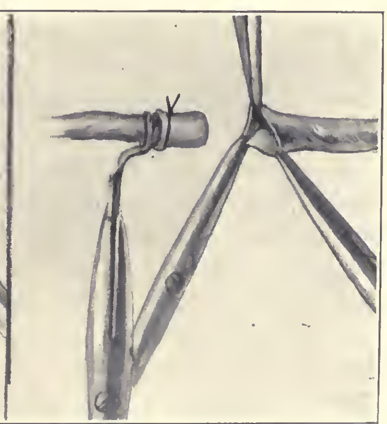

Fig. 16.

Fig. 16.—The vein has been cuffed back and tied, and the artery is about to be drawn over the cuff.

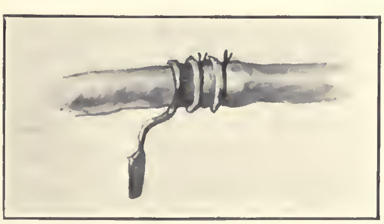

Fig. 17.—The cuff of the vein is tied near the handle of the cannula. The cuff of the artery is tied in a groove between the middle ridge and the end of the cannula.

through which sutures applied to the ends of the artery can be carried to aid in the eversion of the artery over the end of the cannula. R. C. Bryan and Ruff devised a modification consisting of splitting the cannula and having one side hinged so the vessel can be laid in, instead of being drawn through the cannula.

TECHNIC FOR DIRECT TRANSFUSION OF BLOOD

The operating tables or stretchers carrying the patient, or the recipient, and the donor, are placed in opposite directions, and in such a position that the left arm of the patient is in easy contact with the left hand and forearm of the donor. The hand and forearm of the donor are in contact with the ulnar side of the forearm of the recipient. Between the two operating tables a small table is placed on which the arms of the donor and the recipient rest. There is a stool for the operator and one on the opposite side of the small table for the assistant. A good light is essential. It is well to talk to the donor and the recipient during the operation to encourage them and sustain their morale. Local anesthesia is used. Three or four drops of a 1 to 1000 solution of epinephrin is added to an ounce of one-half of one per cent procaine solution. Too much epinephrin makes bad healing. A region about 3 inches long over the lower part of the radial artery of the donor is infiltrated with the local anesthetic and the radial artery is exposed through an incision with sharp knife dissection. Every bleeding point is clamped with mosquito forceps. It is essential to have the field as dry as possible. The radial artery is handled gently and the little branches that come from it are doubly clamped with mosquito forceps, divided and tied with fine black silk. The radial artery is ligated with catgut at the lower end of the incision and at this point dissection of the artery should be quite close to the wall of the vessel. Farther up, however, it is better to include as much tissue around the artery as possible, as this prevents somewhat the contraction of the artery during dissection and decreases the chances of injuring the arterial wall itself. The blood is stripped up with the finger and thumb from the radial at the lowest point of the wound to the highest point and the artery is clamped at the upper portion of the wound with a serrefine or bulldog forceps whose pressure has been so regulated that it will occlude the artery without injuring its intima. This pressure can previously be adjusted by clamping the serrefine on the skin of the forearm of the operator and so changing the pressure of the instrument by bending its spring that it will hold to the skin firmly without producing pain. The artery and the wound are then covered with gauze wrung out of salt solution, and the vein in the recipient is exposed. This is done by grasping the anesthetized skin over a prominent vein just below the elbow with a pair of thumb forceps, lifting it from the vein and cutting off the apex of the cone of skin that is within the grasp of the thumb forceps. This oval exposure can be extended by a straight incision in either direction. If possible a vein should

be selected that has a branch near the proposed point of anastomosis. A ligature is placed on the vein at the lower extremity of the wound, a mosquito forceps on the branch, a serrefine on the vein at the upper angle of the wound, and the vein is divided.

The radial artery of the donor is then divided just above its ligature and, if suturing is to be done, the ends are prepared for suturing as described in Chapter VI on Suturing Blood Vessels. If a Crile cannula (Fig. 13) is to be used one or more fine sutures are placed in the end of the vein which is threaded through the cannula, entering at the handle end (Fig. 14). It is then brought out and everted into a cuff by traction on three or four fine sutures or hooks in the end of the vein or by mosquito forceps and turned back as far as possible on the cannula, where it is secured by a ligature of silk near the handle of the cannula (Fig. 15). It is important to keep the lumen of the vein about the center of the cannula, for if it is drawn too much to one side the pressure of the blood current may form a pocket or valve and greatly retard or stop the flow. The cannula, which is manipulated by holding its handle with hemostatic forceps, is transferred to the radial artery of the donor, which has been cut just above the ligature and has been seized at three points around its lumen with mosquito forceps (Fig. 16). The open artery is drawn over the cannula and secured by a ligature of silk, thus opposing the vascular endothelium of the donor to that of the patient (Fig. 17). The serrefine on the vein is first removed and then the serrefine on the radial artery. The current is turned on slowly at first and stopped at intervals if the flow seems very full or if there is evidence of cardiac distress, such as pain in the left chest, difficulty in breathing, or bluish color on the part of the patient. The donor should also be carefully watched, his blood pressure taken at intervals and if his color changes markedly and suddenly, transfusion should be at once checked by application of a serrefine on his radial artery. If the donor's condition does not improve after waiting a short time, the transfusion is discontinued.

Usually, with a robust donor, a flow of about fifteen or twenty minutes is all that is necessary. It is better, however, to transfuse as much blood as the patient and the donor will stand. When the transfusion is discontinued the radial artery is ligated with catgut and the vein of the patient is similarly ligated and the connection containing the anastomosis or cannula is cut away. The wound is closed with silk or silkworm-gut. Union is likely to be poor on account of the infiltration with anesthetic, the manipulations over the wound, and the interference with the nutrition of the tissues in the neighborhood of the cut radial artery.

So far as the effect upon the patient is concerned direct transfusion either by suture or by the cannula of Crile is, of course, identical. If the operator has had some experience in suturing blood vessels, suturing is probably better than the use of the cannula, for the union between the artery and the vein can be manipulated or dilated by introducing through the

venous branch a probe, which cannot be done when the cannula is used. Then, too, if for any reason the union is unsatisfactory and has to be cut away and another attempt at union made, much less of the artery and vein is sacrificed by the suture method than by the cannula method.

Some surgeons prefer to use the vein-to-vein transfusion instead of the artery-to-vein. The union is made in a similar way only a vein is exposed in the donor instead of the artery and the distal end of the vein of the donor is united to the proximal end of the vein in the patient. A light tourniquet to compress the vein but not the artery in the arm of the donor is kept in place during the transfusion to promote the flow of the venous blood from the donor.

While the rich, oxygenated blood from the artery of the donor seems more desirable for transfusion than the venous blood, there appears clinically to be but little difference and the danger of dilatation of the heart in the vein-to-vein transfusion is much less than in the artery-to-vein method.

In the *semidirect method* a tube or cannula is used and the blood instead of flowing directly from the vascular endothelium of the donor to that of

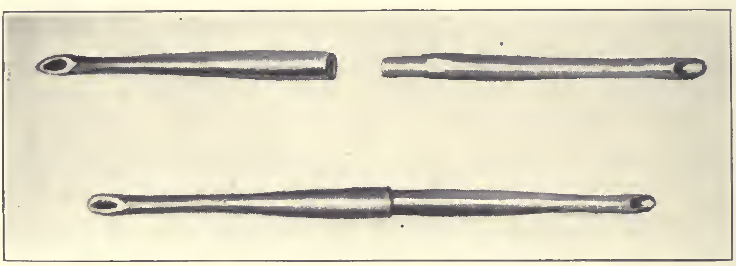

Fig. 18.—Bernheim's cannula for transfusion.

the patient flows over an intermediate foreign substance which is the inner wall of the connecting tube. This tube may be made of glass, as recommended by Brewer. It is tied into the end of the artery or vein in the donor and into the vein of the recipient and the flow established as after the direct method. Care should be taken to see that the tube has been boiled in paraffin oil just before it is used so as to lessen the tendency of the blood to clot in the cannula. One spurt of blood is permitted from the donor before the cannula is applied to the patient's vein in order to exclude the air.

The most convenient form of cannula, if the semidirect method is chosen, is that of Bernheim. This consists of a silver cannula in two parts, a male and a female part, which fit accurately into each other. The ends terminate obliquely and bluntly, so they may be more readily inserted into the vessels. The end of the male half, which is for the donor's artery, is slightly smaller than the end of the female half. It can be used for vein-to-vein transfusion as well as artery-to-vein (Fig. 18).

It is used as follows:

The two halves are disconnected and boiled in mineral oil. The male half is inserted into the artery of the donor through a slit in the side of the

artery or into the cut end of the artery, as preferred. The female half is similarly inserted into the vein of the recipient. Each half is secured by a ligature. The two halves are filled with salt solution to exclude air, fitted to each other, and the blood current is turned on. This cannula method of Bernheim is very satisfactory. It can be done almost as easily as the citrate method. One half of the cannula may be inserted in the donor in the operating room and the donor taken to the patient's room after the other half of the cannula has been tied into the patient's vein. The donor is placed

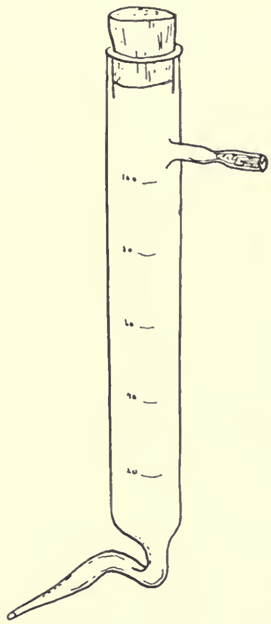

Fig. 19.—Kimpton and Brown's cannula for transfusion.

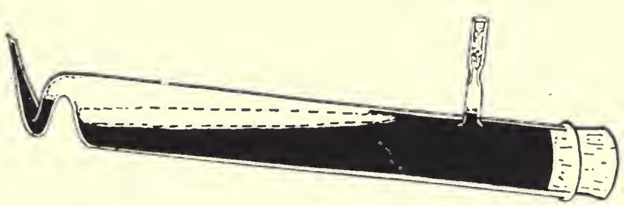

Fig. 20.—Kimpton and Brown's cannula in horizontal position, showing the trap which prevents the entrance of air in the cannula.

in a comfortable chair and the two halves are connected. The blood goes directly over unmixed with chemicals and if the proper grouping of blood has been made there is never any reaction. The technic is simple. I am now using this method almost exclusively.

The *indirect method* of transfusion has in recent years dominated the field. Without anticoagulant mixtures this method is represented by a type of container such as the Kimpton and Brown, or the Percy apparatus, which is coated with paraffin, filled with blood from the donor, and then

emptied into the vein of the patient. (Figs. 19 and 20.) Another indirect method consists in the aspiration of blood from the vein of the donor into a syringe which is immediately emptied into the vein of the patient. This is called the method of Lindeman, who inserts a small cannula in the vein of the donor and a similar one into the vein of the recipient. Blood is rapidly drawn out by the syringe from the cannula in the donor and quickly emptied into the vein of the recipient. This requires skillful assistance and a series of syringes, which must be cleaned with salt solution after each emptying.

There are many theoretical objections to indirect methods because very little is known of the actual physiologic changes in the blood. Even so gross a change as clotting has not been thoroughly explained. It seems probable then, that when blood is withdrawn from contact with its vascular endothelium and, particularly, when it is mixed with foreign chemicals, changes occur, which, though too fine to permit of chemical detection, alter the biologic function of the blood. That some such changes do occur is evidenced by the fact that when citrated blood is used the coagulation time of the patient's blood is markedly decreased. As coagulation is dependent upon certain definite chemical changes and as these in turn require the presence of some materials which result from injured cells, it is evident that destruction or injury of cells occurs, which thereby releases thrombokinase, or prothrombin, that is essential to the fibrin ferment of coagulation. This element of fibrin ferment is always derived from injured cells, probably chiefly from the platelets of blood. However, as the important constituents of transfused blood seem to be preserved intact in the citrate method and as clinically the citrate method gives about the same results as other methods in restoring the hemoglobin of the recipient, theoretical objections should not militate too greatly against the very simple method of citrate transfusion of blood, as devised by Lewisohn. The marked reaction is the chief objection.

The technic of introducing this blood is identical with that of intravenous infusions of salt solution or Locke's solution. Unless the hemoglobin is too low or the condition of the patient too desperate, intravenous infusion of Locke's solution should be applied before resorting to transfusion.

The recipient should be prepared for the blood before the blood is drawn from the donor. The patient needing the transfusion is usually so anemic and the veins are so collapsed that it is best to insert a cannula into his vein through a short incision. This is made under local anesthesia, lifting with thumb forceps the skin over a vein near the elbow and cutting away the apex of this elevated cone of skin. (Fig. 21.) This leaves an oval wound. A ligature is applied around the vein at the lowest portion of the wound and tied. Another ligature is placed around the vein at the upper portion of the wound but is left untied. The wall of the vein is grasped with a small thumb forceps or mosquito forceps and incised obliquely. (Fig. 22.) The intravenous cannula or, in an emergency, a medicine dropper which is attached by a rubber tube to a glass container or to an irrigating can containing about 100 c.c. of Locke's solution, is then inserted into this opening

in the vein while the solution is flowing. The ligature at the upper end of the wound, which was thrown around the vein but not tied, is tightened around the cannula. The cannula is inserted, flowing, to avoid the introduction of air. Sometimes when the insertion is a little difficult the opening in the vein can be made

Fig. 21.—The skin is caught up over a prominent vein in front of the elbow and the apex of the skin is cut away with scissors.

Fig. 22.—A ligature has been tied on the distal side of the vein, another ligature placed but not tied on the proximal side, and the vein has been opened with an oblique incision.

more conspicuous by inserting a closed mosquito forceps and opening the forceps, or by catching the edges of the opening with two mosquito forceps and pulling the wound open, or by inserting a grooved director and pushing the cannula along the grooved director. Sometimes one of these manipulations is easier

than another and sometimes none of them is required. It is always well, however, to be prepared for any one of them. After about 50 c.c. of Locke's solution have run into the vein the citrated blood is poured into the container and the flow continued. If the flow is too rapid it is checked at intervals. When only 25 c.c. remain in the container, more Locke's solution is poured in so that all of the citrated blood will flow into the vein without the danger of the entrance of air. If the amount of blood is not sufficient more blood can be obtained in a similar way and introduced through the same cannula. As a rule, however, 500 c.c. of citrated blood are sufficient.

In obtaining blood for the citrate method a cannula within a cannula is introduced into the donor's vein, which is distended by applying a tourniquet lightly to the arm. There are special cannulas for this purpose on the market, which consist of a very small cannula containing a wire that does not reach the end of the cannula. This is fitted into a large cannula. After introduction, the wire is withdrawn and if the blood flows through the small cannula, this is withdrawn, leaving the larger cannula in position. Usually the median cephalic vein in the region of the elbow is selected. The large cannula must be of sufficient caliber to permit the blood to flow freely and not to drop. If it drops from the cannula it is likely to clot.

Sometimes the donor's vein, if not large, is transfixed with a straight round needle to hold it steady. If there is difficulty in introducing the cannula into the donor a short incision may be made and the vein exposed. If the vein has been rendered sufficiently prominent by cording and the cannula has been introduced obliquely in the general course of the vein, usually there is no trouble in securing a good flow, which can be increased by having the donor work his fingers or by adjusting the tourniquet.

The blood is collected into a graduated glass jar containing 50 c.c. of 2 per cent citrate of sodium and 1 per cent sodium chloride solution. This is sufficient for 450 c.c. of blood which will make a total bulk of 500 c.c. of citrated blood. The inside of the graduate is thoroughly moistened with citrate solution, so that when the blood touches its side it will not coagulate. The flow of the stream is directed to the center of the graduate as nearly as possible and the blood is thoroughly mixed as it flows, by stirring it gently with a glass rod. Care should be taken to draw no more than 450 c.c. of blood to the 50 c.c. of 2 per cent solution of citrate of sodium, otherwise coagulation will take place. To be on the safe side it is better to draw a little less than 450 c.c. of blood. It will also be found that if the donor is excited the blood may have a greater tendency than normal to coagulate and an additional allowance of citrate solution should be made.

The chief clinical objection to the citrate method is that there are more chills than after other methods. Lewisohn thinks that about 20 per cent of citrate transfusions are followed by chills. Others find a larger percentage of reactions. It is, of course, taken for granted that the proper tests have been made for agglutination and hemolysis between the donor and the recipient.

CHAPTER VI

SUTURING BLOOD VESSELS

The field of blood vessel suturing has contracted considerably in recent years. The indications for suturing wounded blood vessels have been considered as follows:

1. Wounded blood vessels where direct suture instead of a ligature is used.

2. Excision of malignant tumors that have heretofore been considered inoperable because of involvement of a large blood vessel.

3. Aneurisms in which the collateral circulation would not be sufficient to sustain the nutrition of the limb if the vessel is tied.

4. Transfusion of blood.

5. Reversal of the circulation.

(1) In the treatment of a wounded blood vessel, particularly a vein, with a lateral wound, direct suture is indicated instead of a ligature. It has been found, however, as an experience of the war, that in young men, who were previously healthy, and in whom the loss of blood was not too great, ligation of the ends of a large wounded vessel close to the injury is, in the great majority of cases, satisfactory. The objections to using blood vessel suturing in military surgery are that in many cases it seems to be unnecessary, and usually, when indicated, the exigencies of the situation are such as to make the technic of blood vessel suturing difficult or impossible to perform. Undoubtedly, in traumatic surgery where cases can be treated in well equipped hospitals and by surgeons who have acquired the proper technic, there will be occasional instances in which suturing of injured blood vessels will be the best treatment for the patient.

(2) In excision of malignant tumors involving large vessels the indications for removing the vessels are not so clear as it would appear. If the vessel has been gradually pressed upon by the extension of the growth and its circulation gradually decreased, collateral circulation will have formed and the involved blood vessel can be excised with much less danger of gangrene than if the vessel had been excised before the collateral circulation had been developed. This is the same principle that is taken advantage of by Halsted and by Matas in the gradual occlusion of large vessels by the use of malleable metal bands, which can be so adjusted as to produce a greatly decreased flow through the vessel. But if the tissues around the vessel are infiltrated and the vessel itself is not materially pressed upon, it would be safer to excise the artery and then suture between the divided ends a segment of vein.

(3) In the treatment of aneurisms the endo-aneurismorrhaphy of Matas

can be applied in almost all aneurisms in which the circulation can be temporarily arrested. In other instances, ligation according to some of the standard technics or the gradual occlusion of the vessels by a malleable band, is usually satisfactory. There may, however, be occasional instances in which on account of enfeebled collateral circulation, excision of the aneurism and suturing a segment of vein between the divided ends of the artery is indicated.

(4) In transfusion of blood, the ideal method would be to transfer the blood from the donor to the patient over a continuous surface of vascular endothelium. The objections to this are the difficulty of the technic, the danger of dilatation of the heart, and the inability to measure the dosage of blood. The indirect method of transfusion by citrate of sodium, which apparently renders the blood incoagulable by combining with the calcium elements in the plasma, is simple, and the cannula of Bernheim seems to be clinically so effective, that there is but little place for suturing blood vessels in transfusion of blood.

(5) The so-called reversal of the circulation for threatened gangrene has been proved to be a fallacy and there is no indication here for suturing vessels.

There are, however, occasional instances in which blood vessels should be sutured or a segment of vein transplanted and it would be well for the surgeon to acquire, knowledge of this technic which can only be gained by experimental work. He will find too, that it improves his general surgical technic and teaches gentleness in handling tissues.

The chief difficulty to overcome in suturing blood vessels is occlusion by clotting, and the whole technic is intended to prevent an excessive amount of clotting while at the same time repairing the walls of the vessel in such a manner that they will withstand the normal blood pressure. If a vessel becomes occluded by clotting at the site of operation it might as well have been ligated. Indeed, a ligature would be safer because a part of the thrombus at the site of clotting in a sutured vessel may become dislodged and interfere with collateral circulation.

In order to appreciate the necessity for certain steps in suturing blood vessels, it is necessary briefly to review the physiology of thrombus formation.

The physiology of thrombus formation is still somewhat vague, though certain general reactions are acknowledged by all physiologists. The formation of a clot or thrombus is due to the action of a material called fibrin ferment, or thrombin, on fibrinogen. Fibrinogen exists normally in the blood plasma. Fibrin ferment is built up of various substances and is formed from the action of a thrombo-plastic substance, called by some thrombokinase, upon thrombogen in the presence of a solution of calcium salts. Thrombokinase is not a true kinase in the sense of acting solely as a ferment, for it is used up in the process of clotting. Thrombokinase is the key to the situation, and whether it acts directly, or indirectly, as Howell claims, by combining with antithrombin in the blood and thus liberating prothrombin (thrombogen), it nevertheless is essential to clotting and to a large extent regu-

lates the amount of thrombus formed. Thrombokinase is supposed to be present in all tissues of the body and also comes from disorganized blood corpuscles, particularly the platelets. It seems abundant in the adventitia of blood vessels, probably due to the fact that this coat of a blood vessel is loose and areolar, and entangles the platelets or blood cells in its substance when bleeding occurs. This seems a provision by which nature attempts to stop hemorrhage.

The practical bearing of these facts upon blood vessel surgery is evident, for thrombokinase can only be liberated from injured cells. As the amount of clotting is directly proportionate to the amount of thrombokinase, it is readily seen that any undue injury to blood vessels by rough handling, or by drying of the endothelial cells of the intima, or by the presence of too much foreign substance in the lumen, or by chemical or bacterial injuries, will result in the liberation of so much thrombokinase that excessive thrombus

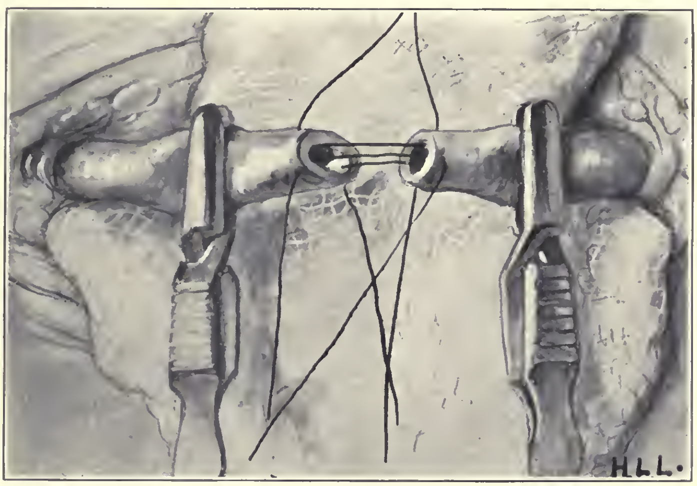

Fig. 23.—The three tractor sutures are placed. (Carrel.)

is formed and the vessel is occluded. Even the most successful suturing of blood vessels is accompanied by some clotting; but a limited amount is essential, as it serves to fill the punctures from the needle holes and to bridge over the line of contact. In successful vessel suturing, however, the injury is so slight that very little thrombokinase is released and consequently only a small amount of thrombus is formed, just enough to plug the punctures made by the needle and not enough to obstruct the lumen.

We recognize, then, as the principles for successful blood vessel suturing that a continuous surface of vascular endothelium must line the lumen of the blood vessels and that as little injury as possible must be done this endothelium.

Probably the best known method of suturing blood vessels was published by Carrel, in 1902. It differs in no essential particular from the work of others, but is a combination of the best features of other work. The results

obtained were much better than those secured by any one else. He used very fine, No. 16, round, straight needles, threaded with fine silk impregnated with vaseline. The adventitia is thoroughly removed and the ends of the artery are washed out with salt solution, or Ringer's solution. The ends of the vessels are then united by three traction sutures inserted around the artery at equidistant points (Fig. 23). Traction on the sutures converts the circumference of the artery into a triangle, approximates the intima, and facilitates the suturing. (Fig. 24). The operator holds one traction suture, the assistant holds another, and the third is caught in a small hemostatic forceps, so as to pull the artery away from the region that is being sutured. After suturing one-third with a continuous overhand stitch the operator takes the traction suture held by the assistant, the assistant takes the one to which the hemostat

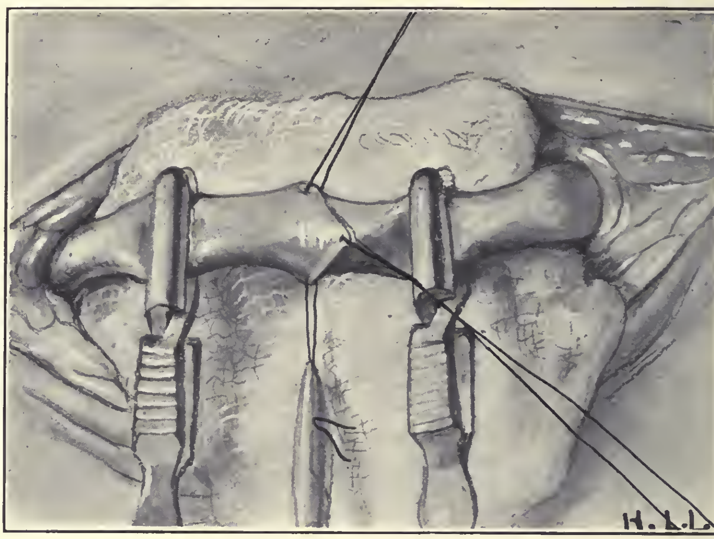

Fig. 24.—The three sutures are tied and the upper third is ready for suturing. (Carrel.)

was fastened, and the hemostat is placed upon the traction suture that the operator originally held. (Fig. 25). After the second third is finished the traction sutures are again changed, the operator taking the one held by the assistant, who makes tension on the suture that was clamped by the hemostat and the hemostat is placed on the suture just released by the operator. The last third is sutured and the blood current is turned on gently. (Fig. 26.) Slight pressure usually stops the oozing from the needle holes, and then the full force of the blood stream is released.

The objections to the method of Carrel are: (1) it is complicated, difficult and requires trained assistants; (2) the sutures are placed under varying conditions of pressure at different points along the line and the transference of the guy or traction sutures during operation is confusing; (3) a very small surface of the vascular endothelium is approximated. In an effort to overcome these difficulties I have devised a technic that in my

hands has proved satisfactory and seems to meet the objections that have been stated.

In suturing blood vessels it is essential to have the least possible trauma

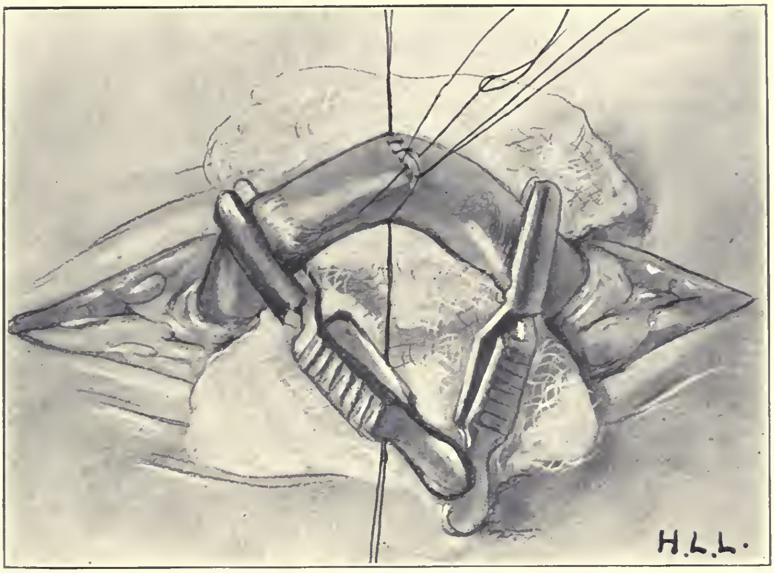

Fig. 25.—The suturing of the upper third is completed. (Carrel.)

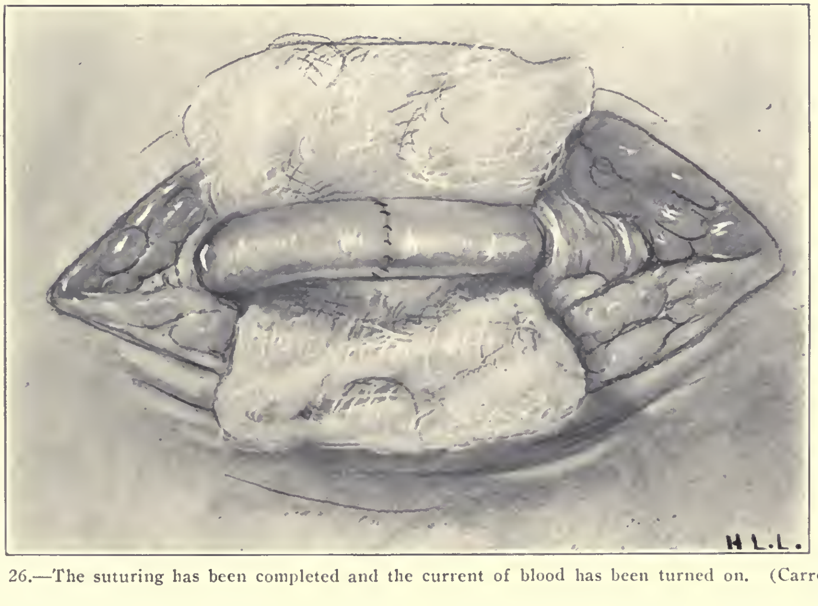

Fig. 26.—The suturing has been completed and the current of blood has been turned on. (Carrel.)

and irritation to vascular endothelium. In order to avoid drying of the endothelium and to prevent contamination of the sutured surfaces with juices from the cut ends of the artery, which contain thrombokinase, it has been

customary to smear the exposed ends of the vessel with vaseline or with paraffin oil, and the stitches are impregnated in this material.

Cubbins and Abt[1] have shown that vaseline, alboline and lanolin are irritating to the peritoneum, as is paraffin oil, though in a lesser degree. These substances appear to promote adhesions instead of preventing them. They show that olive oil, while not preventing adhesions, has no irritating effect and is absorbed. If this is true of the peritoneal endothelium, it is probably also true of vascular endothelium. Besides the irritating effect which would follow clotting, these substances act as foreign bodies, do not dissolve in the blood stream and may cover injured cells or thrombokinase which will later cause local thrombus formation.

To avoid these objections I have abandoned the use of vaseline in blood vessel suturing, except that the arterial needles and threads are boiled in vaseline. This seems necessary for the arterial sutures are so fine that they will not run smoothly through the tissues unless lubricated and vaseline is an excellent lubricant for this purpose. Olive oil is a poor lubricant. The small amount of vaseline that adheres to the thread is largely covered by the approximated vessel walls when a double mattress or cobbler's stitch is used and so very little or none of it appears in the lumen of the vessel.

The importance of presenting to the lumen of the vessel a continuous surface of vascular endothelium, is appreciated when we recall what has been learned in a somewhat coarser fashion in intestinal suturing, where it is a well recognized principle, as it is in blood vessel suturing, that the endothelial surfaces must be approximated accurately. In the bowel, the endothelium is on the *outside* and it is necessary to turn *in* a small flange or shelf to secure accurate apposition of the peritoneal endothelium. In blood vessels the endothelium is on the *inside* and it is essential to turn *out* a flange in order to approximate the endothelial lining of the blood vessel. The usual method of suturing blood vessels consists in first placing three guy sutures and then whipping the edges of the vessel together by an overhand stitch. This necessarily cannot approximate the endothelial surface on the inside as accurately as would a mattress stitch which turns out a flange and compels the apposition of the intima. No one would think of suturing a bowel in a similar manner and claim that the peritoneum could be accurately brought together by merely whipping over the margins of the bowel wound as in suturing skin. If this cannot be done in intestinal surgery, the same thing holds equally in blood vessel surgery.

The presence of foreign substances in the lumen of a blood vessel promotes clotting. Some substances favor clotting more than others. Other things being equal, however, the larger the amount of foreign substance or raw surface in the blood vessel, the greater the likelihood of extensive clotting. A mattress suture that turns out a flange not only approximates the intima more accurately but leaves almost no thread exposed in the lumen; whereas the continuous overhand stitch leaves a considerable amount of thread in the

[1]Surg. Gynec. & Obst., May, 1916, pp. 571-579.

lumen. This is readily seen from the accompanying cut (Figs. 27 and 28) which is reproduced from Guthrie's work on blood vessel surgery and shows the inside of the vessel soon after being sutured by the usual method. The mattress suture which is parallel to the wound also secures a better hold upon the tissues than the overhand stitch which is at right angles to the wound, and the mattress stitch is, consequently, less liable to cut (Figs. 27 and 29). This is due to the fact that in the mattress suture the tension is more equally distributed along the whole loop of the stitch, whereas in the overhand stitch the tension is concentrated at one point, that is, at the end of the suture farthest from the wound. This fact has been brought out by Lexer, who excised an aneurism and sutured a piece of the saphenous vein into the defect. He said:[2] "The wall of the artery markedly changed by arteriosclerosis allowed the threads of the running suture of Carrel to cut through. On the other hand, the continuous protruding mattress suture

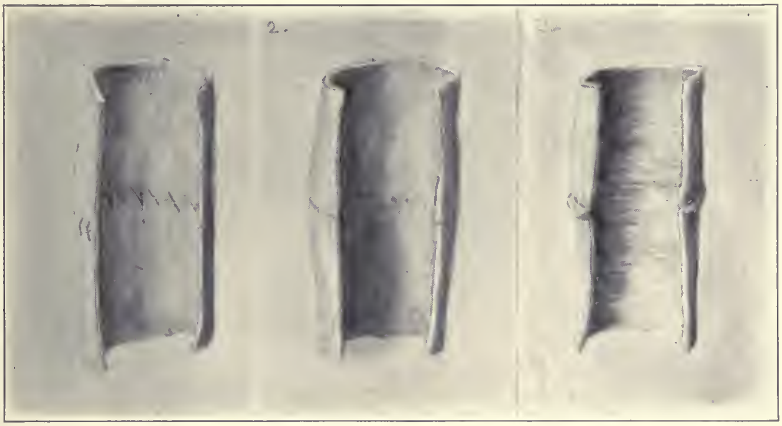

Fig. 27. Fig. 28. Fig. 29.

Fig. 27.—This drawing, reproduced from Guthrie, shows the lumen of a blood vessel immediately after it has been sutured by the method of Carrel. Note large amount of thread exposed in the lumen.

Fig. 28.—This drawing, also from Guthrie, shows the lumen of a blood vessel several weeks after successful suture. The stitches have been covered by endothelium, which is still transparent. The older the specimen, the thicker and more opaque is the covering over the sutures, until after several months the stitches are completely hidden. This seems true of any method of suturing, but it is the first few days after suturing that the amount of thread exposed in the lumen is important. Sutures seem to work away from endothelial surfaces toward the lumen in the intestines and toward the surface in blood vessels.

Fig. 29.—This drawing shows the eversion produced by the double mattress stitch and the consequent absence of any raw surfaces in the lumen of the vessel. Note the small amount of thread exposed to the blood current, as compared with Fig. 27, and the strong grip that the loop of the mattress stitch has on the tissues.

gave very good service; the thread not only held well but also prevented hemorrhage."

Asepsis in blood vessel suturing should be as nearly perfect as possible, just as it should be in abdominal surgery, brain surgery or bone surgery. If the tissues around the blood vessels are infected no suturing can be expected to be satisfactory. Yet even in the presence of infection blood vessel suturing is not invariably a failure, as I have one successfully sutured femoral artery in a

[2]Lexer: Jour. Am. Med. Assn., May 10, 1913, p. 1474.

dog in which the tissues around the vessel suppurated for several weeks. As a rule, however, infection will result in failure and the proper aseptic technic should be insisted upon. Particularly should dust be avoided. The operator should wear a mask over his mouth and the floor of the operating

Fig. 30.—Special instruments used in the author's method of end-to-end suturing of blood vessels. On the left is the arterial suture staff, and next to it is a small thumb forceps called "frog" forceps. On the right is a "mosquito" hemostatic forceps, and next to it two serrefines, or "bulldog" forceps.

room should preferably be moist. In laboratory work the floor should be flushed with water an hour or two before operating. The manner of handling tissues is most important, for gentleness is an absolute essential. No matter how careful the aseptic technic, good results cannot be secured by

one who uses the same methods of handling tissue in blood vessel surgery as would be adopted in bone surgery. The vascular endothelium must not be permitted to dry, or should it be touched with any instrument.

As for instruments, I use No. 16 straight needles threaded with 00000 twist black silk. They are threaded with silk about fourteen inches long and a single knot is tied on the eye of the needle to prevent it becoming unthreaded. The short end should be cut within half an inch of the needle to avoid unnecessary loose ends dangling about. Five of these threaded needles are run through a piece of gauze of double thickness about two inches wide and as long as the thread. This gauze is then placed in a small can or

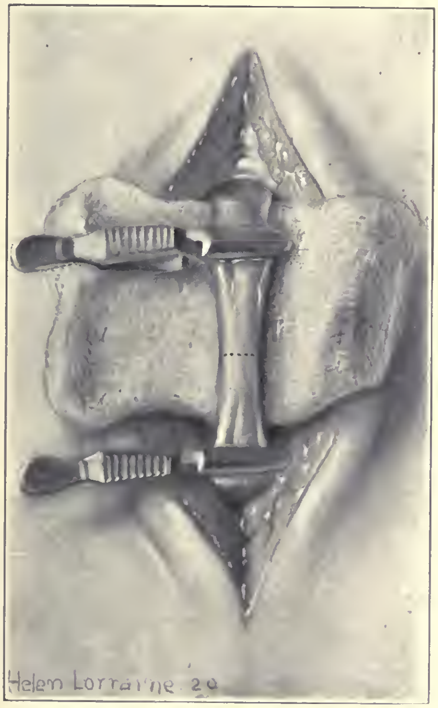

Fig. 31.—The artery is exposed, blood stripped from it, and serrefine clamps are placed. Plain gauze is under the artery. The dotted line shows the proposed incision.

Fig. 32.—The artery has been severed by sharp scissors and the adventitia which curls over the ends of the artery is pulled down and cut away with scissors.

ointment jar that is one-half full of white vaseline, and the jar is closed and sterilized. The needles are not removed until they are to be used, when they are taken from the gauze.

To place the cobbler's stitch satisfactorily, it is necessary to have an instrument called "an arterial suture staff" which I have devised in an effort to simplify the technic. This instrument (Fig. 30) consists of a small steel shaft which curves at one extremity into a shorter shaft. The long shaft, or handle, is six inches long, and the short shaft is one and three quarter inches long and is placed at an angle of about sixty degrees to the long

shaft. The curved portion is flattened to form a spring. There are five buttons; one on the main shaft as close as possible to the curved spring, one at the extremity of the short shaft, one just below this, and two on the main shaft at points about opposite the buttons on the short shaft. These buttons hug the instrument closely and are so constructed that the guy sutures are securely held by simply wrapping them twice around the buttons. In order to occlude the vessel, either a rubber covered Crile clamp is used, or the ordinary serrefine, or bulldog clamp, uncovered, which has a spring so weakened that the clamp can grasp the skin of the forearm without

Fig. 33.—The thumb and finger of the left hand grasp the end of the artery after the adventitia has been cut away, and olive oil is dropped on the artery.

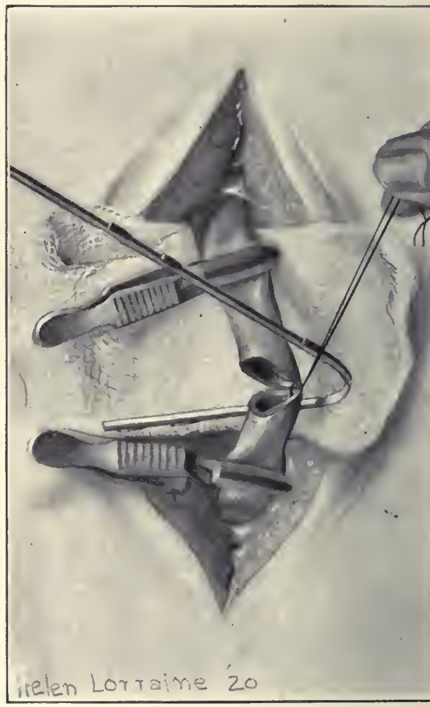

Fig. 34.—The first suture has been placed and is wrapped around the lowest button on the long shaft and cut short.

pain. The inside of the blood vessel should never be caught with forceps, though sometimes it is necessary to grasp the outside. For this purpose the ordinary thumb forceps called "frog forceps" by the instrument dealers and sold for biologic dissection are excellent. Several mosquito hemostatic forceps are needed (Fig. 30). Aside from these special instruments, the usual instruments may be employed. The knife and scissors should be sharp.

The vessel is exposed, keeping the tissues as dry as possible. A serrefine is placed on the portion of the vessel nearest the heart, and the vessel is gently grasped between the thumb and finger and stripped of blood to the

other angle of the wound, where another serrefine is placed. This leaves the artery dry and flat like a ribbon. Dry gauze or gauze wet with salt solution now is placed beneath the vessel (Fig. 31), after stopping all bleeding in the wound, and the artery is divided with one stroke of sharp scissors. The fingers are wiped free of blood and moisture on a dry towel and the left finger and thumb grasp one of the ends of the artery firmly and pull the adventitia over its cut end. The adventitia is cut off on a level with the rest of the artery (Fig. 32). It then retracts, leaving the middle and inner coats exposed. Any remaining clots in the vessel are stripped out with the thumb and finger and the end is held firmly between the thumb and finger of the left hand and

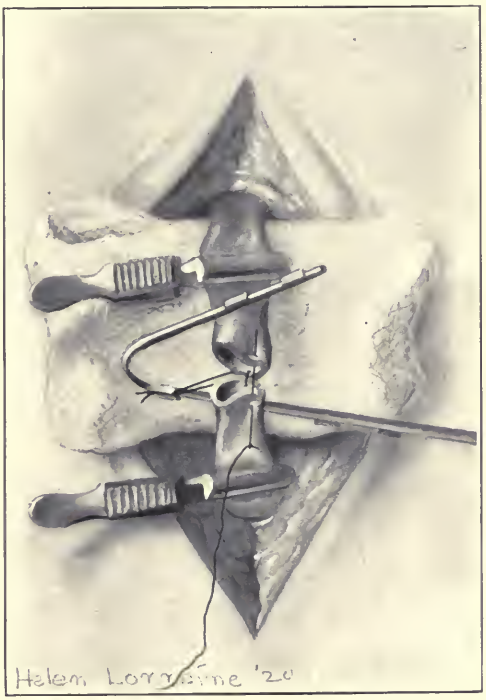

Fig. 35.—The handle of the arterial suture s.aff is depressed away from the operator and the short shaft may be turned flat and caught so as to manipulate the ends of the artery into a convenient position for inserting the second suture. The second suture is inserted, tied, and wrapped around one of the upper buttons on the long shaft.

sponged with dry gauze. As the artery is collapsed and its end held between the finger and thumb the gauze cannot touch the intima, but merely wipes the wounded portion and so removes any excess of thrombokinase. Olive oil is dropped on the end of the vessel with a medicine dropper (Fig. 33). This washes away the tissue juice containing thrombokinase, and prevents drying of the intima.[3]

All of these manipulations are done rapidly for it is essential to complete the suturing as quickly as possible after the intima has been exposed.

[3]Horsley, J. S.: Olive Oil in Blood Vessel Suturing, Ann. Surg., April, 1918, pp. 469-471.

One of the sutures, which has been prepared as directed, is inserted from without inward at one end of the artery and from within outward at the other end. An artery is quite tough and a small bite will be sufficient. If too big a bite is taken, the intima cannot be properly everted. The first loop of a knot is tied, bringing the ends of the vessel together. The second loop of the knot is tied while holding the ends of the suture taut, running the knot down in this manner to prevent the first loop slipping. Olive oil is dropped on the vessel ends every 20 or 30 seconds to prevent drying. After tying this suture, the arterial suture staff is placed under the artery

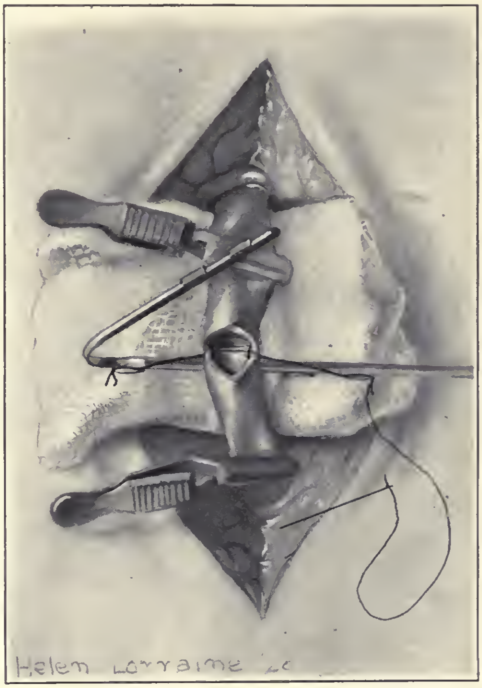

Fig. 36.—The threaded end of this second guy suture is left long for future suturing. The unthreaded end is cut short. The vessel can now be lifted on the staff and the apex of the retracted margins indicates the point of insertion for the third guy suture. The staff makes the insertion of the second, and, particularly, the third guy suture much easier.

with the short shaft pointing toward the operator. Each of the buttons of the staff is daubed with vaseline to make the sutures hold better when wrapped around the buttons. The vaseline should not touch the intima of the vessel. The guy suture is fastened by wrapping it two or three times around the lowest button on the long shaft, and is cut short (Fig. 34). The length of the suture from the button to the vessel should be about half an inch. The second suture is placed about one third of the distance around the circumference of the vessel and should be on the side away from the operator. The suture staff is laid flat so that the short shaft is not in the way and the vessel ends rest upon the long shaft, thus making it easier to place the second

suture (Fig. 35). The second suture is inserted and tied in the same manner as the first and is wrapped around one of the upper buttons on the long shaft. The threaded end is left long for future suturing, but the other end is cut close to the button. As two guy sutures are now fixed to the long shaft, the third one is easily inserted by raising the long shaft, when the point of insertion of the third suture is indicated by the retraction of the margins of the artery. The needle is inserted at the apex of the retracted margin (Fig. 36).

Fig. 37.—After insertion of the third guy suture, it is tied in the usual manner and the staff is grasped by the handle as indicated in this drawing, and, while the short shaft is slightly compressed toward the long shaft, the third guy suture is wrapped around one of the buttons on the end of the short shaft.

After this suture is tied, the short shaft is slightly compressed toward the long shaft and this guy suture is wrapped around one of the buttons on the end of the short shaft (Fig. 37). The threaded end is left long and the unthreaded end is cut close, as was done in the second suture. It is important to have no unnecessary ends hanging loose. The short shaft is released and the spring makes tension on the margins of the artery, converting its circumference into a triangle, and everting the intima (Fig. 38). Olive

oil should be dropped on the vessel ends from time to time during these manipulations and during the suturing.

The three guy sutures are inserted in the same way when an artery is joined to a vein of much larger caliber as when a divided artery is united. Sometimes it is a little more difficult to place the guy sutures properly when a small artery is sutured to a large vein as in direct transfusion, but after the guy sutures are once inserted, the rest of the procedure is identical, whether vessels of equal or unequal caliber are to be united.

We now have two needles from the two guy sutures last inserted. A

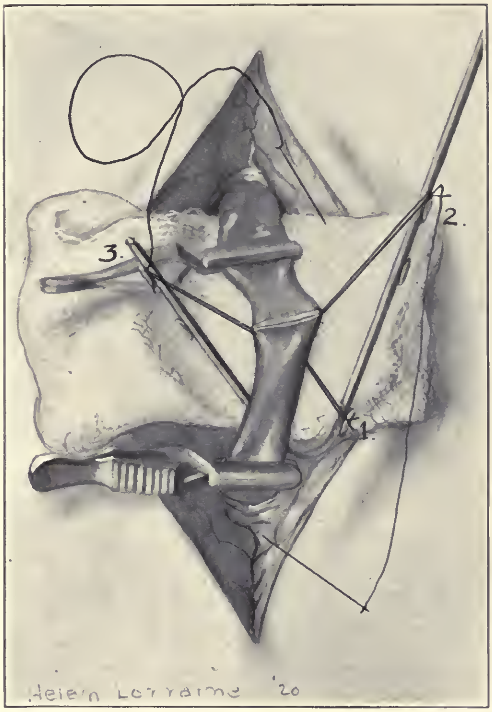

Fig. 38.—When the tension of the spring of the shaft is released by removing the hand, the spring makes traction on the three guy sutures, so converting the circumference of the vessel into a triangle, and everting the intima.

needle is taken in each hand and thrust through both margins of the artery in the region where the second suture was tied. The threaded needle from the third guy suture at the end of the short shaft, will, of course, carry a little loop of thread which is of no consequence. The instrument is lifted so as to elevate the upper third of the arterial wound and increase the eversion. The suture is then applied in the manner of the double mattress, or cobbler's stitch, going from the second guy suture to the third (Fig. 39). At the angles particular care should be taken to go beneath the insertion of the guy sutures; otherwise, the tension of the guy sutures may produce a wound in the endothelium which would be exposed to the lumen of the vessel. After the

first third has been sutured, the handle of the suture staff is depressed away from the operator and the staff shoved toward the operator so as to increase the eversion of this third of the margin of the vessel (Fig. 40). The suturing is continued as a cobbler's stitch. When the second third is finished, the instrument is brought to its original position and each needle is carried under the vessel so as to be ready for suturing the last third. The handle is then depressed *toward* the operator and held in such a manner as to lift up the last third and so increase its eversion (Fig. 41). The suturing is continued through the last third and when this is finished the instrument is brought

Fig. 39.—The handle of the staff is upright and the whole instrument is lifted up so as to increase the eversion of the intima. The continuous double mattress or cobbler's stitch is begun by using the threaded ends of the last two guy sutures. The needles are thrust through the margins of the artery near the second guy suture and are inserted at right angles to each other, so they can be more readily handled. The suturing in this third is done toward the operator—that is, from the second to the third guy suture.

to its original position and the suturing carried about two stitches beyond the point of beginning, where the threads are tied to each other. Each stitch must be drawn snugly when it is placed, else the intima will not be securely approximated and there will be leakage. In the carotid of a dog of medium size about five stitches are put in each third of the artery.

Sometimes retraction of the ends of the artery is marked and the sutures cannot be properly placed, as they will tend to cut out or break under the tension. If the adventitia of the vessel is grasped with curved mosquito forceps about one and one-half inches from the severed ends, the two ends of the

vessel can be shoved together by an assistant, without tension on the sutures and without his hands being in the way of the operator. This is better than trying to approximate the ends by the serrefine clamps which may either come off or loosen and flood the vessel with blood.

After the suturing has been completed, the short shaft is slightly compressed toward the main shaft so as to relax the tension on the guy sutures and the *distal* clamp on the vessel is slowly released (Fig. 42). If there is marked spurting at any point, an extra suture is placed there. With a little experience spurting rarely occurs, though there is usually oozing of a few drops of blood. The guy su-

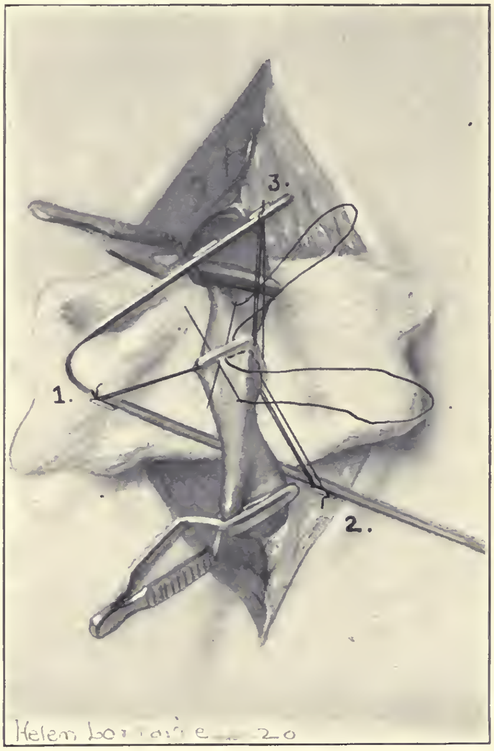

Fig. 40.—The handle of the staff is depressed until it is horizontal and points away from the operator. Then the whole instrument is shoved toward the operator so as to increase the eversion of the second third. The suturing is continued as a cobbler's stitch.

tures are then cut and the instrument is removed. The sutured vessel is very gently compressed with dry gauze and the distal clamp is entirely removed. After about three minutes the proximal clamp is slowly removed. In this time the needle holes should be plugged with fibrin and there should be no leakage. The vessel must not be returned to its bed until leakage has ceased. The whole procedure of suturing the vessel from the insertion of the guy sutures to the last stitch, can easily be done in from ten to fifteen minutes and often in less time. Any competent surgeon who tries this technic experimentally a few times can master it (Figs. 43 and 44).

The transplantation of a segment of a vein, or of an artery, involves the same technic as suturing a divided vessel. It is best, however, to have two arterial suture staffs instead of one. Three guy sutures should be placed at one end, but only the first two fastened to the staff. Then the other end of the transplant can be sutured with another staff in the usual way. After this is completed, the first staff is taken up, and the third guy suture fastened to the end of the short shaft, and the suturing completed. In this way there is no inconvenience from the presence of two suture staffs in the wound at the same time, for if all three guy sutures were placed in position on the first suture staff, the short end of the staff would project so as

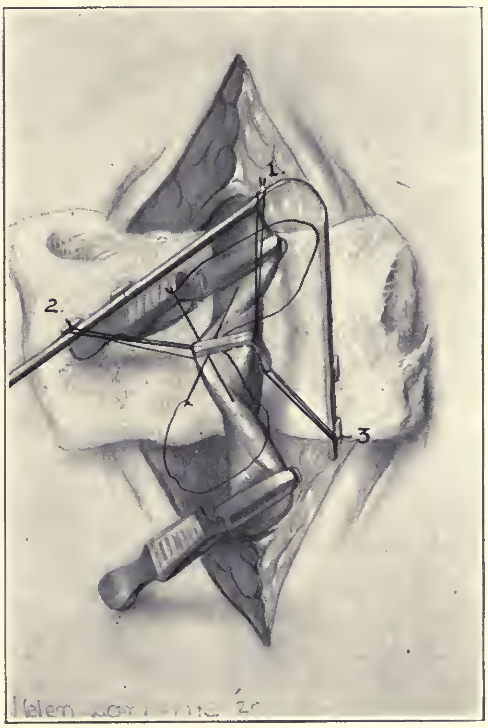

Fig. 41.—The handle of the staff is brought over to a horizontal position, pointing toward the operator. The instrument is lifted up so as to increase the eversion in the last third. The suturing is continued from the first to the second guy suture.

to interfere with the suturing at the second suture staff. A transplant can be taken from either a vein or an artery. For practical purposes the vein is better. In experimental work the external jugular of the dog is the most suitable vein to transplant. It is readily accessible, is large, and has but few branches. Transplantation after resection of the carotid is more likely to be successful in experimental work than transplanting in the femoral because the neck is much less likely to be infected than the leg (Figs. 45 and 46). This has been pointed out by Stephen Watts.

Some attention must be given to securing a section of the vein that

is to be transplanted. The saphenous is the best vein to use as a transplant in man. The vein must be exposed and handled gently. A much longer portion should be taken than is supposed to be necessary, for it contracts greatly after being removed and it is a simple matter to cut off any excess if it is too long. The vein is dissected free while it is distended with blood and the adventitia of that portion of the vein to be cut is very carefully removed while the vein is distended; otherwise it retracts within the adventitia and as the vein is exceedingly thin, cleaning away the adventitia is

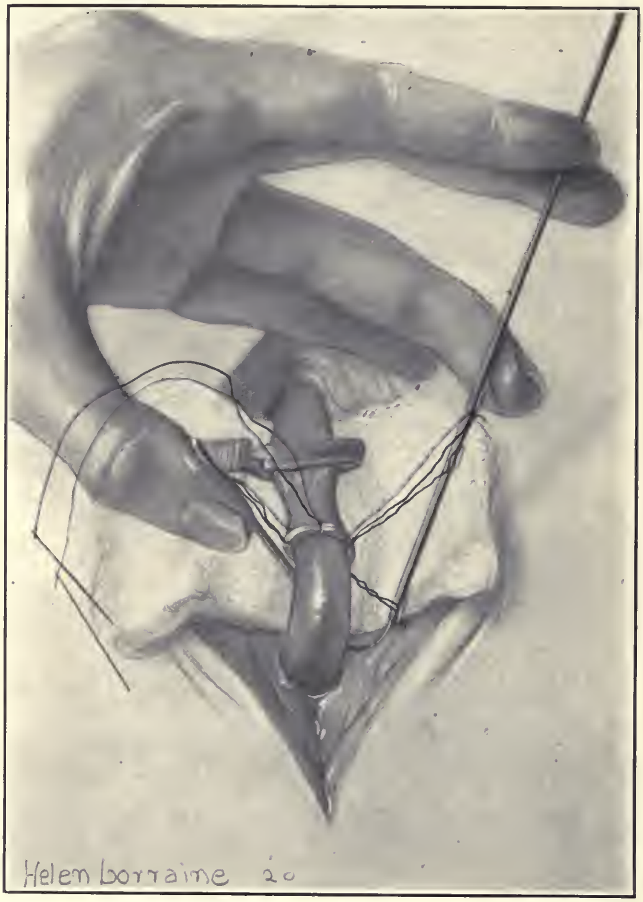

Fig. 42.—The handle of the instrument is brought to a vertical position and the sutures, having been carried about two stitches beyond the point of commencement, are tied to each other. The distal clamp is slowly removed and the staff somewhat compressed in order to relax the guy sutures and demonstrate if there is any spurting point along the suture line. After a minute the other serrefine is removed if no spurting occurs, and the guy sutures are cut. If there is spurting, the clamps can be reapplied and an extra stitch taken at the spurting point.

difficult after the collapsed segment has been removed. When the adventitia has been sufficiently removed, the serrefine that caused the vein to become distended is released and a ligature is placed on the distal portion of the vein. The blood is then gently stripped out of the vein and another ligature

placed at the proximal end. The vein is severed with sharp scissors, with one stroke if possible. After the blood has been stripped from the vein it is entirely collapsed and like a ribbon. When the end is cut it is sponged with dry gauze and thoroughly anointed with olive oil, as mentioned in the technic for vessel suturing (page 79), only more olive oil should be used here. The other end is then divided and treated in a similar manner. The vein should be used as quickly as possible. The vein should not be removed until the other dissection has been completed, so that suturing of the vein into the defect can be proceeded with at once. The segment of vein should not be washed out or kept in salt solution. If for any reason it is necessary to keep the segment a while, it may be placed on a towel or piece of gauze that has been wrung out in salt solution, and another piece of gauze similarly wrung out, is placed over it. It is not

Fig. 43.

Fig. 44.

Fig. 43.—A femoral artery of a dog removed a few minutes after suturing, after the blood had been turned on and no leakage appeared. Note the eversion of the intima which makes a flange without diminution of the caliber.

Fig. 44.—The lumen of the carotid artery of a dog after suturing according to the author's technic. The blood had been turned on and allowed to run a few minutes. Note the small amount of thread in the lumen.

necessary for the salt solution to be warm. It has been proved that cold tends to retard thrombus formation, and segments of vessels can be kept in cold storage for weeks and then sutured successfully.

I have used experimentally rubber tubing of various kinds to replace an arterial segment. This, in most instances, becomes readily covered with tissue that resembles the adventitia of a blood vessel. It is well known that rubber when properly prepared is very slightly irritating to the tissues. Dentists make frequent use of it. If, then, adventitia can be thrown around the rubber tube as an encapsulation, it would probably support the blood

current after the rubber had degenerated. The high reproductive power of vascular endothelium is frequently observed in the rapid lining of aneurisms that have suddenly enlarged, and it seems possible that this endothelium might cover the inner surface of the rubber tubing. Theoretically, in this way a strong adventitia and an intima may be secured. Experimentally, however, I have not been able to obtain such a result. Though the tube is often encapsulated with a membrane that resembles adventitia, its internal

Fig. 45.

Fig. 46.

Fig. 45.—The end of the carotid artery was sutured to the distal end of the divided external jugular vein in a dog, and this specimen was removed after thirty-nine days. The sutures are distinctly buried, though the endothelium over them is transparent in places. The line of suturing is smooth. A short distance from the line of suturing are the crumpled up valves which were broken down by the blood stream.

Fig. 46.—A segment of the external jugular vein was sutured in the place of a resected portion of the carotid of a large dog. The valves are about the middle of the specimen, and at this point the transplanted vein was dilated. Otherwise, the intima is smooth and the sutures mostly buried from view. The specimen was removed sixty-three days after operation.

surface has so far been invariably blocked, sooner or later, by thrombus. Tubes have varied from thick, black rubber to very thin rubber, and have been coated with vaseline or paraffin. While it would be impossible to suture tubes, especially thick tubes, by the overhand stitch, and at the same time

make an accurate approximation and avoid sharp edges of the tube pointing inward, by using a mattress suture, and preferably the double mattress with the staff, that has been described, sharp edges are everted. While so far I have not met with success in having the rubber tube remain permanently patent, the thrombus formation in some instances at least must have been slow. Clinically it is almost as satisfactory to have a slowly forming thrombus in a tube

Fig. 47.—Photograph of a specimen in which a rubber tube was sutured into the defect caused by excision of a portion of the abdominal aorta of a dog. This specimen was removed after six months, and the tube, which had been sutured according to the method described, was completely encapsulated, though occluded.

of this character, which would permit collateral circulation to form, as it is to have the tube remain permanently open.

The possibility of using a rubber tube in this manner clinically has been suggested by an experiment in which a portion of the abdominal aorta of a dog was resected and a piece of rubber tube transplanted to fill the defect. The portion resected was below the renal arteries. The tube was a soft, black rubber tube coated with paraffin. It was much thicker than was really necessary, and the suturing was more difficult than if a thinner tube had been used. The dog was a medium sized female mongrel. There was very little leakage, which was easily controlled by pressure. The peritoneal tissues were sutured over the tube. The dog made a satisfactory recovery, there being no paralysis of the hind legs. As function had apparently not been interfered with, it was hoped that the tube had remained patent. Six months after this operation the dog appeared in perfect health. The dog was then photographed, killed with chloroform, and the specimen removed. The lumen of the tube, however, was occluded with a thrombus. There was no dilatation nor any evidence of formation of an aneurism. The outline of the tube is plainly seen in the photograph. The external caliber of the tube was considerably larger than the external caliber of the artery (Fig. 47).

Ligation of the aorta in man has been universally fatal. This experiment suggests a possible substitute for ligation.

LATERAL AND INCOMPLETE TRANSVERSE WOUNDS OF BLOOD VESSELS

The preliminary steps in suturing lateral or transverse wounds of blood vessels are the same as those outlined under the description of end-to-end suturing. The wound should be a clean cut. If ragged or bruised, the margins are trimmed with sharp scissors. If a transverse wound involves more than half the circumference of a vessel, the vessel should be completely divided and then united by the end-to-end method. If the whole circumference is contused or laccrated, the damaged section must be excised, and if the ends of the vessel cannot be sutured together without too much tension, a transplant of vein may be used.

The method to be adopted in suturing these wounds depends partly upon the nature of the wound, but largely upon the accessibility of the blood vessel. When possible, the vessel should be freely exposed by a long excision. The adventitia along the edges of the wound is trimmed away with sharp scissors, blood clots are removed, and the edges of the wound and the intima are washed with Locke's solution. If the wound is parallel with the vessel, it may be grasped with the forceps used for lateral anastomosis of blood vessels or arteriovenous ancurism and sutured with a cobbler's stitch, using fine, straight needles (No. 14 or 16) and fine black silk sterilized in vaseline. If the wound is transverse, the suture staff may be placed under the vessel, a guy suture of the usual material is inserted at one end of the wound and

wrapped around an upper button on the long shaft, and another guy suture is placed at the opposite end of the wound and fastened to a button on the short shaft while it is being compressed toward the long shaft. When the short shaft is released, it will make tension on the wound and evert the intima. A cobbler's stitch can then be placed with the threaded ends of the guy sutures, as in suturing the first third of an end-to-end union. Care should be taken to secure the beginning of the suture line by going well beyond the wound and taking a back stitch. Occasionally a transverse or a lateral wound may be so inaccessible that neither of these methods can be used. Here a long guy suture may be placed at each end of the wound and held by an assistant while the wound is closed with a continuous overhand stitch of black silk in a fine curved, round needle. There will be more leakage from the needle-holes after this method and thrombosis is more frequent, but in deep wounds it may be the only technic applicable.

CHAPTER VII

REVERSAL OF THE CIRCULATION

The therapeutic value of attempts to reverse the circulation in the extremities has been freely discussed since this work was first brought to the attention of surgeons by the experiments of Carrel. Carrel and Guthrie[1] reached the following conclusions as the result of two experiments; "(a) The valves prevent, at first, the reversion of the circulation in the veins. (b) After a short time, the valves gradually give way and the red blood flows through the veins as far as the capillaries. (c) Finally it passes through the capillaries and the arteries are filled with dark blood. Probably dark blood also returns from the capillaries towards the heart through some veins. (d) Practically complete reversal of the circulation is established about three hours after the operation."

The clinical indication for reversal of the circulation has been thought to be threatened or slow gangrene of the foot or occasionally of the hand. The lower extremity is far more frequently threatened with gangrene than the upper extremity. This may be due to the fact that it is longer and the distance from the base of nutrition is consequently greater and that the circulation has to overcome the weight of the column of blood that must be lifted from the foot, which is far greater than would be the pressure of the returning blood circulation from the upper extremity.

The diseases in which slow or threatened gangrene usually occurs are; (1) arteriosclerosis, (2) intermittent claudication, (3) Raynaud's disease, and (4) thromboangiitis obliterans. In all of these diseases the artery is usually more profoundly affected than the vein. It has been suggested as a result of the experimental work of Carrel and Guthrie that the vein could take on the function of the artery, and in slow or threatened gangrene of the foot the femoral artery could be divided in its upper portion, the femoral vein also divided at a same level and the cardiac end of the artery sutured to the distal end of the vein, the distal end of the artery being sutured to the cardiac end of the vein. In this way the blood in the femoral artery enters the femoral vein and is supposed to overcome the obstacles of the valves in the vein, gradually to reach the terminal veins and capillaries, and then is returned through another system of veins that would anastomose with the branches of the iliac veins.

In order to determine the exact course of the reversed circulation, a series of experiments on dogs was undertaken, the results of which have been reported elsewhere.[2] The late Dr. R. H. Whitehead, who was Professor of

[1]Ann. Surg., February, 1906, p. 212.
[2]Jour. Am. Med. Assn., March 13, 1915, lxiv, 873-877; Ann. Surg., March, 1916.

Anatomy in the University of Virginia, dissected the specimens and reported that the dissections corresponded in all essentials with the roentgenograms.

DeWitt Stetten, of New York, worked on the same problem using limbs that had been amputated for affections in which reversal of the circulation

Fig. 48.—A roentgenogram of reversal of the circulation in a dog's hind extremity which was injected with cinnabar mass a half-hour after operation. The mass goes only a little below the knee and returns in the back part of the thigh toward the branches of the internal iliac vein.

Fig. 49.—A roentgenogram of cinnabar mass which was injected into the reversed circulation of a dog's hind extremity twenty-two days after the operation. Note the very large collateral veins that conduct the mass easily to the iliac veins and the vena cava.

Fig. 50.—A roentgenogram of cinnabar mass injected into reversed circulation of the hind extremity of a dog sixty-nine days after the operation.

Fig. 51.—A roentgenogram of the same dog shown in Fig. 50, but with the systemic arterial system injected with a bismuth mass through the carotid. Note the excellent circulation in the foot. The black shadow in the body is due to rupture of some abdominal vessel toward the end of this injection which permitted the peritoneal cavity to be filled with the bismuth mass.

had been formerly recommended.[3] In his excellent article, which goes very fully into the literature of the subject, he arrived at the same conclusion which we had reached by our experimental work on dogs.

Briefly summarizing the results of these experiments, thirteen dogs were operated upon by severing the femoral artery and femoral vein just below Poupart's ligament and suturing the cardiac end of the artery to the distal end of the vein by the technic described in the previous chapter. This technic stands infection better than the technic of Carrel, as it apposes a broader surface of endothelium and makes a firmer and more resistant union. These dogs were killed within periods of time, varying from half an hour to sixty-nine days after the operation. The femoral artery just above the point of the anastomosis was injected with a cinnabar and gelatine mass under considerable pressure. Roentgenograms were then taken and afterwards the general arterial circulation was injected with a bismuth mass either from the aorta or the carotid. Both bismuth and cinnabar are impervious to x-ray and the difference in color prevents confusion in dissection. In no instance did the reversed circulation, as shown by the injection of the cinnabar, go as far as the foot and in every case except one it extended but a short distance below the knee. The tendency of the arterial blood in the reversed femoral vein is to return to the vena cava by the nearest anastomotic route (Figs. 48, 49, 50 and 51). The longer the period of time after the operation, and the more abundant the collateral circulation, the easier is the return to the vena cava.

Evidently what happens is that the large valves in the large veins are first quickly broken down. The arterial blood in the reversed vein then rushes into smaller veins. The smaller valves in the smaller veins require relatively more force to overcome them than the larger valves in the large veins, because of the relation of cubic contents to square surface. The experiments show that the reversed circulation went but little further down the leg in a dog sixty-nine days after operation than it did in the dog that was injected a half hour after the circulation was reversed. This seems to show that the valves which are not broken down in the first few minutes will probably hold permanently. Collateral circulation quickly increases, and large veins are formed which readily carry the reversed blood to the branches of the iliac vein. In this way the pressure upon the obstructing valves is reduced and probably some thickening of these valves occurs. Instead, then, of the constant pounding of the heart tending to break down these valves, it seems to do just the opposite. Valves that are not overcome within the first few minutes have less and less pressure upon them until the collateral circulation develops to its maximum.

How, then, can we account for the apparent improvement in many of the reported cases of reversal of the circulation in patients? Certainly not all of these reports can be argued away, and they must rest on some basis of fact. In the successful cases reported, it has been usual to find that the day after the operation the foot appears warmer and the color is better than

[3]Surg. Gynec. & Obst., April. 1915.

before operation. It has been asserted, therefore, that the improvement must be accounted for by the operation and by the fact that the arterial blood is reaching the distal part of the foot through the reversed vein. A great many reversals of the circulation have been done by surgeons untrained in blood vessel surgery who have used the end-to-end method, and it is natural to expect that there will be a large percentage of occlusions by thrombosis following such work. In no other branch of surgery is laboratory experience so essential as in preserving a patent lumen after suturing blood vessels. It is easy enough to unite the artery and vein so that the line of union will not bleed at the conclusion of the operation, but the technically successful operation is the one in which the lumen remains permanently patent. These temporary improvements may be explained in the following manner:

The cause of the impending gangrene for which these operations are done is a diminished lumen of the artery, while the veins are but little if at all affected. An artery that would normally carry 100 per cent of its capacity is under these altered conditions carrying only, say 25 per cent, but the capacity of the vein has been but slightly altered. Nutrition for the tissues is taken from the arterial blood in the capillaries and depends not only on the quantity and quality of this blood and the ability of the tissues to absorb it, but also to some extent on the length of time during which the arterial blood bathes the tissues. With the artery working normally and the veins normally, a definite period of time during which the arterial blood remains in the tissues is maintained; but with the capacity of the artery cut down to about one fourth of normal or even less, and the capacity of the vein but slightly interfered with, the small amount of arterial blood that does reach the tissues is drained away by the unobstructed veins more quickly than normal. The arteriovenous anastomosis stops the venous current in the femoral vein either by the force of the reversed arterial blood stream or, more probably, particularly when done by those inexperienced in vascular surgery, by thrombosis at the site of the operation. This, of course, obstructs the vein and more nearly restores the balance between the venous and the arterial circulation. In other words, the operation dams back the arterial blood in the capillaries so that instead of being drained off too rapidly, the arterial blood is compelled to stay the normal time, and possibly even somewhat longer than normal, and so gives up to the tissues more of its nutrient properties. In this manner the improvement as to the color and warmth of the affected limb can be accounted for. But if the occlusion has been caused by thrombus formation at the arteriovenous anastomosis, the thrombus may extend until too much of the venous system is plugged, and gangrene will follow.

The same results can be obtained much more accurately and with less danger simply by ligation of the femoral vein under a local anesthetic. This procedure has been recommended and carried out by von Oppel, Coenen, Lilienthal and others.

In operation for threatened or slow gangrene of the foot, the femoral vein should be ligated below the point at which the saphenous vein enters it in

order not to obstruct too much of the returning venous circulation. As the condition of the patients with threatened or slow gangrene is serious the operation should be done under local anesthesia.

An incision of about three inches in length is made over the upper portion of the femoral artery beginning just below Poupart's ligament. The dissection is carried down until the femoral artery is fully exposed in the lower half of the incision. The femoral vein is identified internal and slightly posterior to the femoral artery and should be cleanly dissected in front with a sharp knife. By the method of inserting closed, curved scissors and then opening the blades the vein can be readily isolated. Care is taken to expose the femoral vein clearly and to have the incision sufficiently long to prevent any confusion of the anatomical structures. A ligature is passed around the femoral vein with an aneurism needle. It is best to apply two ligatures of moderately stout catgut. The skin is sutured with silk or silkworm-gut. The leg is slightly elevated and kept warm. Within twenty-four hours there is often marked improvement in the condition of the limb. This improvement is usually not permanent. The beneficial results, however, are fully as great as those obtained from anastomosing the artery and vein, and the danger of the operation is far less.

CHAPTER VIII

LIGATION OF BLOOD VESSELS

One of the chief indications for ligation of the blood vessels in preantiseptic days was secondary hemorrhage following suppuration. This indication is infrequent now, so the elaborate operations that were formerly devised for ligation of almost every artery in the body are largely unnecessary.

On account of aneurisms there is often occasion for tying in continuity the larger arteries, as the carotid or its branches, subclavian, axillary, brachial, iliac, femoral. Occasionally, on account of hemorrhage from the palmar arches it is necessary to tie the radial and the ulnar arteries.

Ligation of arteries in continuity requires a clear knowledge of the anatomy of the site of operation. The general technic of ligating vessels holds good for the tying of any artery. The incision should be made as directly over the vessel to be ligated as possible. This should be determined in advance and is based upon the anatomy of the parts. Any probable or possible variation in anatomy from the normal must be borne in mind and the anatomical changes that may be produced by the pathology present, as in ligating in the presence of great swelling, must be given due consideration. The incision should be sufficiently long to expose the vessel freely and, as a rule, should be so placed that the proposed site of the ligation of the artery will be in the center of the incision. The skin incision is made by holding the skin firmly with the fingers and thumb of the left hand and cutting through the skin in the proposed line of the artery with one stroke of the knife. The superficial fascia and deep fascia are then divided. All vessels that are in the way are retracted or else doubly clamped and ligated, so as to give a clean access to the artery. When approaching close to the artery, the loose connective tissue and areolar tissue are caught with thumb forceps and lifted and cut with a sharp knife. It is dangerous to dissect around a big vessel with a dull knife, because the stroke of a dull knife cannot be gauged with accuracy. The artery is usually distinguished by pulsation if no tourniquet is used, or, if a tourniquet is used, by the fact that the artery is thicker and not collapsible as the vein is. Below the axilla and below the knee each artery has two companion veins, the venæ comites, which may serve as an identification, whereas the larger arteries in the head and neck are accompanied by single veins. The nerves appear as white solid cords. Occasionally, a nerve may transmit pulsation because it rests on an artery, but if grasped gently between the finger and thumb it can be easily seen that this is not an expansile pulsation but merely transmitted.

Only the main larger arteries have a distinct sheath. Usually when there is a sheath, the accompanying vein and nerve are enclosed in a common sheath

with the artery. The smaller arteries have no distinct sheath, but are merely surrounded by areolar tissue. In the large arteries the sheath should be opened at least half an inch from any branch. The sheath is opened by picking it up with thumb forceps, making traction upon it so as to pull it away from the artery and dividing it by a stroke of a sharp knife in the axis of the vessel. It must, of course, be accurately ascertained before dividing the sheath that the forceps does not include the vessel wall also. This is not likely to occur but can be easily demonstrated by moving the sheath to and fro. It is best not to make an incision into the sheath longer than is necessary to ligate the vessel clearly, as too extensive a separation of the sheath from a large artery may interfere with the nutrition of the walls of the ar-

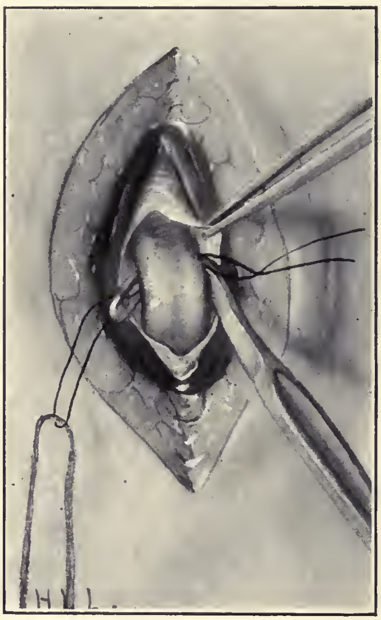

Fig. 52.—Binnie's method of passing a stout catgut ligature.

tery. If necessary, it is better to open the sheath by making two short incisions at different points than to make one long incision.

The ligature is passed preferably with a curved aneurism needle. It may, however, be more convenient to use a small right angled pedicle clamp. The only objection to the clamp is that, when its jaws are opened to receive the ligature and then clamped on the ligature, it is possible that some tags of tissue in the neighborhood may also be caught in the forceps and prevent the free moving of the forceps. This can usually be prevented by opening and closing the forceps several times before placing the ligature in its grasp. In a deep wound, however, the aneurism needle is preferable to the right angled forceps. The aneurism needle should be passed around the artery beginning on the side of the vein. In the larger arteries, moderately stout cat-

gut is used. If this is threaded into the aneurism needle before the needle is passed, it may interfere with passage of the needle. It is a good idea to follow the suggestion of Binnie and arm the needle with a fine thread of silk or linen which does not hamper the manipulation of the aneurism needle. When the eye of the aneurism needle has appeared on the opposite side of the vessel from that under which it was inserted, the loop of small silk or linen is drawn up and the stouter catgut is passed through this loop and so drawn around the vessel (Fig. 52).

Ligatures of catgut are usually best and if tied properly the knot will hold. The so-called surgeon's knot should never be used because it is impossible to tell how much pressure is being taken up by the friction of

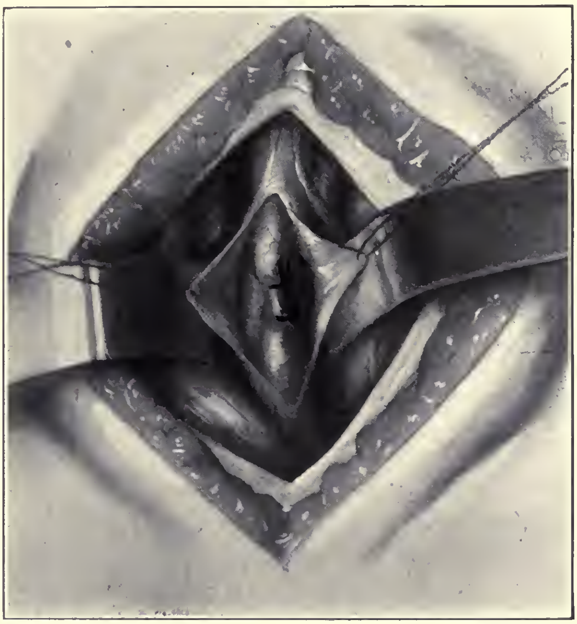

Fig. 53.—Ligation of the femoral artery, showing method of applying two ligatures. The ligature nearest the heart takes the chief strain of the arterial pressure.

the double tie and how much by the vessel. The first tie can be held by grasping it with small forceps, such as mosquito forceps, while the second tie is being run down, and a third tie should always be placed in order to make the knot more certain. It is not necessary to rupture the intima but sufficient pressure should be made by the first tie in order firmly to occlude the vessel. If too large a strand is used there is much more likelihood of the knot slipping than with a smaller strand. It must be recognized, however, that a very small strand may not stand the strain of the pulsation of the vessel or may tend to cut through the vessel walls.

Two ligatures should always be placed at a distance of about one-fourth of an inch from each other. This consumes but little more time and adds greatly to the safety. If only one ligature is passed there is constant pounding

upon it by the impact of the arterial current and healing is consequently more difficult. When two ligatures are placed, the one nearest the heart takes up the strain of the arterial impulse, while the tissues within the grasp of the second ligature can heal more readily because they are at rest and freed from the constant pounding of the heart. Then, too, if the first ligature should loosen it will at least probably hold long enough for a clot to form between the two ligatures and this clot will act as a buffer between the impulse of the arterial current and the second ligature and so reduce the strain on the second ligature. (Fig. 53.)

In tying the ligature and in all manipulations of the artery it is important to move the artery from its bed as little as possible. This is true of all vessels, but it is particularly important when the vessels are diseased, as the slightest interference with the nutrition of the wall of a diseased vessel may result in secondary hemorrhage. The wound should be closed as after any operation, so as to eliminate as far as possible dead spaces but not to place too great a burden upon the tissues by unnecessary suturing.

An artery should be tied as far as possible from a large branch or else the branch should be ligated also.

If a large arterial trunk of an extremity is ligated the limb should be wrapped in an abundance of cotton and slightly elevated so as to favor the return venous flow and consequently prevent passive congestion.

LIGATION OF THE INNOMINATE ARTERY

This artery is sometimes, though very rarely, ligated for aneurism. It is the largest branch of the arch of the aorta and is about two inches in length. It rises opposite the fourth dorsal vertebra, runs upward, forward, to the right, and divides into the right common carotid and the right subclavian. It terminates on a level with the upper border of the right sternoclavicular articulation. In front of this artery are the manubrium with the muscles that arise from this bone, the right sternoclavicular joint, the remains of the thymus gland, the left innominate vein, the right inferior thyroid vein and the lower cervical branches of the right vagus to the heart. Posterior are the trachea and right pleura. To the right are the right innominate vein, the right vagus nerve and the right pleura. To the left are the left common carotid, the remains of the thymus gland, the left inferior thyroid vein and the trachea.

There are several operations for tying the innominate artery. One is by the angular incision of Mott, which is made along the upper margin of the clavicle, the sternomastoid muscle being cut, and another incision from the inner end of this goes upward about three inches along the anterior border of the sternomastoid. An excellent approach can be obtained by an oblique incision along the lower part of the anterior border of the sternomastoid which is carried over on the manubrium. The common carotid is exposed and followed down to the clavicle and then a portion of the manubrium may be divided or resected. A sufficient amount of the bone is taken away in order to give a sat-

isfactory exposure. It has been proposed to split the manubrium and part of the sternum with a saw, protecting the tissues beneath by a flat retractor, slipped under the bone. The important point is, first to recognize the common carotid and then follow down to the innominate. It is best to tie both the common carotid and the vertebral artery after tying the innominate in order to avoid secondary hemorrhage and to reduce the circulation in the aneurism as much as possible.

LIGATION OF THE COMMON CAROTID ARTERY

The right common carotid is about three and three quarter inches in length and arises from the innominate artery. It contains in its sheath the internal jugular vein, which lies to the outer side, and the vagus nerve, which lies between and behind the artery and the vein. The omohyoid muscle crosses the common carotid and the portion of the artery below the omohyoid muscle is deeper than the portion above it.

The left common carotid is longer than the right, being about four and one-half inches long, and arises from the middle of the arch of the aorta and courses upward and outward. It is overlapped by the left lung and pleura in its first portion. The omohyoid muscle crsses on the left side as on the right. The left common carotid has in its deep portion in front, the manubrium with the muscles that arise from this bone, the remains of the thymus and the left innominate vein. Behind the left common carotid in the chest are the trachea, esophagus, the thoracic duct, and the recurrent laryngeal nerve. To the left are the pleura and lung, the left vagus nerve and the left subclavian artery. Internally are the innominate artery, the trachea, remains of the thymus gland and the inferior thyroid vein. In the neck both common carotids have a similar relation, being covered by skin, platysma, fascia, the neck muscles that arise from the sternum, the anterior jugular vein and several superficial veins, which are sometimes irregular, as well as the lingual and facial veins as they course across the artery. *In front* also is the descending branch of the hypoglossal nerve. *Behind* are the vagus nerve, the sympathetic nerves and the cervical branches of the sympathetic to the heart, the recurrent laryngeal nerve, the inferior thyroid artery and the deep muscles of the neck, the longus colli and the rectus capitis anticus major. *Externally* are the internal jugular vein and the vagus nerve. *Internally*, is the trachea below, then come the esophagus, recurrent laryngeal nerve, branches of the inferior thyroid artery, the thyroid gland, the larynx and the lower part of the pharynx.

The line of the common carotid artery can best be expressed by a line drawn from a point just external to the sternoclavicular articulation to a point about the middle of a line between the angle of the jaw and the tip of the mastoid process. The first portion of this line as high as the upper border of the thyroid cartilage represents the common carotid. Normally there are no branches from the common carotid except the terminal branches. If the common carotid is to be ligated below the omohyoid muscle an incision about

three and one-half inches in length is made in the line of the artery from just below the larynx to the sternoclavicular articulation. After cutting through the skin, fascia and platysma, the superficial veins that are encountered are pushed aside or doubly clamped and divided. The deep fascia is incised along the anterior border of the sternomastoid, which is retracted outward. The sternohyoid muscle is either retracted inward or divided. The inferior thyroid veins are doubly clamped and tied. The sheath of the artery is then exposed. The recurrent laryngeal nerve which lies to the inner side must be guarded against as well as the vagus nerve and the internal jugular, or the outer side.

Above the omohyoid, an incision of about three and one-half inches in length is made along the anterior border of the sternomastoid muscle with its center on the level of the cricoid cartilage. Superficial veins are retracted or clamped and divided. The anterior jugular and facial veins should be looked after. They are of considerable size and are doubly clamped or tied and divided. The sternomastoid muscle is retracted outward and the omohyoid downward and inward, or the omohyoid may be divided. The sheath of the artery is carefully cleared and divided from the inner side to avoid the descending branch of the hypoglossal nerve and the internal jugular vein. Ligatures should be passed from the internal jugular vein inward (Fig. 54).

LIGATION OF THE EXTERNAL CAROTID ARTERY

The external carotid artery is the smaller of the two terminal divisions of the common carotid and is about two and one-half inches in length. It lies behind the upper part of the line of the common carotid artery and terminates in the substance of the parotid gland, just in front of the external auditory meatus, where it divides into the internal maxillary and the temporal arteries.

The important structures *in front* of this artery are the anterior border of the sternomastoid muscle, the hypoglossal nerve, the lingual and facial veins, the posterior belly of the digastric muscle, and, higher up, the branches of the facial nerve and the carotid gland. Externally, besides these structures, is the internal carotid artery. *Behind* are the internal carotid artery, the styloglossus muscle, the glossopharyngeal nerve, and the pharyngeal branches of the vagus and the superior laryngeal nerve. *Internally* are the hyoid bone and the pharynx, the submaxillary gland, the parotid gland, and the ramus of the inferior maxilla.

It is well known that the branches of the external carotid are irregular. It was formerly considered that they were so irregular that ligation of this artery should not be undertaken. John A. Wyeth, of New York, in a series of brilliant dissections proved that this was not true, but that the variations of these branches were definite and according to regular laws, and that ligation of the external carotid could be safely undertaken. Before he established these facts it was customary to ligate the common carotid when tying the external carotid seemed indicated.

This artery may be ligated either above or below the digastric muscle, the place of election being below the digastric. An incision is made about three inches long just behind the anterior border of the sternomastoid muscle and from the level of the middle of the thyroid cartilage to near the angle of the jaw. If the sternomastoid muscle is large, approach to the artery is made easier by splitting the fibers of the muscle and so going directly down to the artery. If the sternomastoid muscle is small it can be readily retracted outward. The posterior belly of the digastric is seen at the upper angle of the wound and then the hypoglossal nerve, crossing the ex-

Fig. 54.—Ligation of the common carotid, external carotid, and the first four branches of the external carotid. If the common carotid is to be tied permanently, two ligatures should be placed.

ternal carotid. The thyroid, lingual and facial veins should be avoided, but if too much in the way, they may be doubly clamped and tied. The ligatures should be placed below the superior thyroid. When tying the external carotid, it is best to ligate at the same time the superior thyroid, the lingual artery and other accessible branches of the external carotid as the collateral circulation is very abundant. Through the same incision, continued slightly upward, the external carotid may be tied above the digastric muscle, though this ligation is rarely indicated (Fig. 54).

LIGATION OF THE SUPERIOR THYROID

The superior thyroid artery is ligated for the therapeutic effect on the thyroid gland in hyperthyroidism. It has been found that the best results are obtained by ligating this artery and its branches, as well as the venous branches at the upper pole of the thyroid gland just as it disappears into this gland. The incision for this ligation is a transverse incision, if possible in a natural crease of the neck, about two inches long and on a level with the central part of the thyroid cartilage. The level of this incision is affected to some extent by the size of the thyroid gland. When the gland is large the incision should be made at a higher level. If both superior thyroid arteries are to be tied at the same sitting, an incision about three inches long is made across the larynx on the level with the middle of the

Fig. 55.—Ligation of the superior thyroid artery. In the actual operation the incision is only about two inches long unless both superior thyroids are to be tied at the same operation, as shown in this drawing.

thyroid cartilage, with its center in the midline of the neck. The inner border of the sternomastoid muscle is retracted outward which exposes the omohyoid muscle. This muscle is rather deep and dissection for it had best be done bluntly by inserting the scissors closed and opening them so as to stretch the tissues apart. When the omohyoid is well identified it is retracted inward, retracting also the sternomastoid outward. This exposes the terminal branches of the superior thyroid artery along with the upper pole of the thyroid gland. These branches are surrounded by a ligature, preferably linen or silk, as catgut in hyperthyroid patients might be absorbed too soon. The ligature is tied as closely as possible to the upper pole of the thyroid gland. It is probably better to place a second ligature a short distance from the first one. The technic of this operation has been developed by C. H. Mayo (Fig. 55).

LIGATION OF THE INTERNAL CAROTID ARTERY

The internal carotid is ligated through an incision similar to that used in ligating the external carotid, except that it may be placed slightly farther externally. The bifurcation of the common carotid is identified and the external carotid exposed and identified by its location and by its branches. The internal carotid does not give off branches in the neck. The internal carotid at its origin is slightly external to the external carotid and then sinks more deeply in the neck. It is tied near its origin, the ligature being passed from the side of the internal jugular vein, care being taken to avoid this vein, the vagus nerve, and the ascending pharyngeal artery (Fig. 54).

LIGATION OF THE SUBCLAVIAN ARTERY

The subclavian artery is usually ligated in its third portion but sometimes in its first part. The ligation of the first part of the subclavian carries a high mortality.

The subclavian on the right side arises from the innominate and is about three inches in length, whereas on the left side it arises from the arch of the aorta and is one inch longer. It is divided into three portions, the first portion extending from its origin to the internal border of the scalenus anticus muscle. On the right side this part is about one and one-fourth inches long and on the left side two and one-quarter inches long. The important structures *in front* of the first portion on the right side are the sternomastoid muscle and the sternohyoid and sternothyroid muscles, the right innominate vein, the internal jugular vein, the vagus and phrenic nerves, and the superior cardiac branches of the sympathetic nerve. *Behind* are the sympathetic nerves, the inferior cardiac nerve, and the recurrent laryngeal nerve, the longus colli muscle, the transverse process of the seventh cervical and the first dorsal vertebra, the apex of the right lung, the pleura, and the neck of the first rib. *Below* are the pleura and lung, the recurrent laryngeal nerve, and the subclavian vein. On the left side the first portion of the subclavian is much longer than on the right, but the relations are much the same as of the first portion of the right subclavian, except that the thoracic duct and the subclavian vein are in front and the common carotid artery is in front and the trachea, the recurrent laryngeal nerve, the left common carotid, the esophagus and the thoracic duct are internal. The second portion of both subclavian arteries is about three-fourths of an inch long and lies behind the scalenus anticus muscle, which separates the subclavian artery from the subclavian vein. Both the first and the second portion of the artery are overlapped by the sternomastoid muscle. The phrenic nerve crosses obliquely the lower anterior surface of the scalenus anticus muscle. The second portion of the left subclavian is very rarely ligated. The third portion of the subclavian is the part that is chosen for ligature if the circumstances will permit. This lies in the subclavian triangle whose borders are the sternomastoid, the outer belly of the omohyoid and the clavicle. The important structures

in front of the third portion of the subclavian are some branches of the cervical plexus, the suprascapular artery, the external jugular vein and its communications, together with the suprascapular and transversalis colli vein and the clavicle. *Behind* are the scalenus medius muscle and the lowest cord of the brachial plexus. *Above* are the brachial plexus and the omohyoid, and *below* is the first rib. The subclavian artery terminates at the lower border of the first rib.

The ligation of the first portion of the subclavian can be done by the same angular incision that is used for exposing the innominate. An incision is made along the anterior border of the sternomastoid muscle about three and one-half inches long and terminates at the right sternoclavicular joint. This is joined at its lower end by an incision of about three and one-half inches along the upper border of the clavicle. The sternomastoid muscle and

Fig. 56.—Ligation of the subclavian artery.

sternothyroid and sternohyoid muscles are divided near the clavicle and the common carotid is exposed. The common carotid is traced down to the bifurcation of the innominate artery. The pleura is protected and pushed downward. The internal jugular vein and the vagus nerve are retracted either inward or outward, depending upon which appears to afford the best access to the site of the ligature. The ligatures are passed from below. It is safer to secure the vertebral artery and the common carotid at the same time.

The third portion of the subclavian artery is ligated by making an incision about four inches long over the clavicle, first drawing the skin down and cutting down on the clavicle, beginning the incision from the posterior border of the sternomastoid muscle. When the skin is relaxed the incision will be found to be about one-half inch above the clavicle. The margins of the sternomastoid and trapezius muscles are identified and divided if

necessary. The external jugular vein is retracted or doubly divided and the veins which empty into the external jugular, as well as the subscapular and transversalis colli veins are divided or retracted. The transversalis colli and the suprascapular artery usually run near the field but they should be carefully preserved if possible for collateral circulation. The outer margin of the scalenus anticus muscle, which lies just under the sternomastoid muscle, is identified and followed down to the artery. The lowest cord of the brachial plexus is exposed and the subclavian vein which lies in front of and below the artery. The pleura must also be guarded. The sheath is opened and the ligature passed from the brachial plexus, avoiding the pleura and the subclavian vein (Fig. 56).

LIGATION OF THE VERTEBRAL ARTERY

The vertebral artery sometimes requires ligation and it should be tied if there is occasion to ligate the subclavian in its first branch. The vertebral is the largest and usually the first branch of the subclavian and is exposed by the same incision as would be used in ligating the common carotid in its first portion. After exposing the sheath of the common carotid this vessel with the internal jugular vein and the vagus nerve is retracted outward and the prevertebral fascia is cut vertically just below the transverse process of the sixth cervical vertebra. A short distance below this point the vertebral is crossed by the inferior thyroid artery. The vertebral artery should be tied a short distance below the transverse process of the sixth cervical, where the artery enters the foramen in this vertebra. The inferior thyroid artery and the recurrent laryngeal nerve are retracted to the inner side and downward and the outer structures are retracted outward.

LIGATION OF THE INFERIOR THYROID ARTERY

In ligating this artery the first portion of the common carotid should be exposed as though it were to be ligated. A vertical or a transverse incision in the skin is made. The transverse incision is half of the "collar" incision for thyroidectomy. Below the omohyoid muscle the carotid artery in its sheath is retracted outward and the tendon of the omohyoid muscle is pulled upward while the thyroid gland and trachea are retracted inward. The inferior thyroid artery will be seen opposite the carotid tubercle, which is the transverse process of the sixth cervical vertebra. The inferior thyroid artery runs behind the common carotid artery at about the same level as the omohyoid tendon crosses in front of the common carotid. The inferior thyroid is ligated as far as possible from the thyroid gland so as to avoid injuring the recurrent laryngeal nerve, which runs behind the thyroid gland. This nerve and the middle cervical sympathetic ganglion should be carefully avoided.

LIGATION OF THE AXILLARY ARTERY

The axillary artery is a continuation of the subclavian and begins at the lower border of the first rib and ends at the lower border of the tendon of the teres major muscle, where it becomes the brachial. The axillary artery is divided into three parts by the tendon of the pectoralis minor muscle, which covers the middle or the second part of the artery. The first part of the artery, which extends from the lower border of the first rib to the upper border of the pectoralis minor, has *in front* the major pectoral muscle, the cephalic vein, the external anterior thoracic nerve, together with lymphatic trunks. *Behind* are the posterior thoracic nerve and the first intercostal space. *Externally* is the brachial plexus, and *internally* is the internal anterior thoracic nerve. The second part which lies behind the pectoralis minor muscle, has *posteriorly* the posterior cord of the brachial plexus and *externally* the external cord, while *internally* are the internal cord of the brachial plexus and the axillary vein. The second part is about one and a quarter inches in length. The third part which is the longest, and is three inches in length, extends from the border of the pectoralis minor to the lowest border of the tendon of the teres major. *In front* are the pectoralis major muscle and the inner root of the median nerve, as well as an external brachial vein. *Behind* are the musculospiral nerve, the circumflex nerve and the subscapularis, the latissimus dorsi and teres major muscles. *Externally* are the outer root of the median nerve, the musculocutaneous nerve and the coracobrachialis muscle. *Internally* are the inner root of the median nerve, the ulnar nerve, the internal cutaneous nerves and the axillary vein.

The part of the axillary artery usually ligated is the third part. When ligation of the first part seems indicated it is usually best to tie the third part of the subclavian. Ligation of the first part, however, can be done by an incision below the clavicle extending from near the outer portion of the sternoclavicular joint to the coracoid process of the scapular. The branches of the acromial thoracic artery should be carefully protected on account of collateral circulation. The major pectoral muscle is divided and the branches of the anterior thoracic nerve with the veins in its neighborhood are retracted upward and outward. The artery here lies between the axillary vein on the inner side and the brachial plexus on the outer side.

The third part of the axillary artery is ligated by an incision about three inches long, which begins at the front part of the apex of the inner wall of the axilla and passes outward and downward along the inner border of the coracobrachialis muscle, the arm, of course, being extended and elevated. The coracobrachialis muscle and the musculocutaneous nerve are retracted out along with the median nerve. The internal cutaneous and ulnar nerves are retracted inward. Venæ comites are generally present at this portion, as well as occasionally the basilic vein. The axillary vein alone may be present at the inner side of the artery if it does not form farther in. The ligatures should be passed from the side of the vein.

LIGATION OF THE BRACHIAL ARTERY

The brachial artery extends from the beginning of the axillary, at the lower border of the tendon of the teres major muscle, to about opposite the neck of the radius. The chief relations are *anteriorly,* the median nerve in the middle course of the artery; *posteriorly,* in the upper portion of the artery the musculospiral nerve, then the superior profunda artery and the inner head of the triceps muscle, the insertion of the coracobrachialis muscle, and the brachialis anticus muscle. *Externally* are the coracobrachialis, which slightly overlaps the artery and the median nerve above, and the belly of the biceps, which also slightly overlaps the artery. *Internally* are the internal cutaneous and ulnar nerves above and the median nerve below. The cephalic vein is constantly internal, as well as the one of the venæ comites.

The middle of the arm is the elective point for ligation of the brachial artery and the course of the artery is indicated by a line from the junction of the anterior and middle thirds of the outer wall of the axilla to the center of the bend of the elbow. An incision about three inches long is made with its center about opposite the middle of the arm and extending along the inner border of the biceps muscle in the line of the artery. The belly of the biceps must be recognized and retracted outward. The median nerve crosses the front of the artery about the middle of this incision and the internal cutaneous nerve is on the inner side of the artery.

If the patient has a well developed biceps muscle it is sometimes rather difficult to expose the artery unless the biceps is well retracted.

LIGATION OF THE RADIAL AND ULNAR ARTERIES

There is practically no occasion to ligate the radial artery except just above the wrist when there is an injury to one of the palmar arches. The two palmar arches, deep and superficial, anastomose so freely that when there is a serious injury to either of these arches it is best to ligate both the radial and the ulnar arteries at the wrist, though sometimes the ligation of the radial artery alone will control the deep palmar arch, which is a continuation of the radial artery; or ligation of the ulnar artery alone will control the superficial palmar arch, which is a continuation of the ulnar artery. The lower portion of the radial artery in the forearm is covered only by skin and fascia *in front,* and *behind* are the pronator quadratus and the anterior surface of the lower end of the radius. *Externally* the radial nerve is at some distance from the artery in the lower part of the forearm. The tendon of the brachioradialis lies to the outer side of the artery and is inserted into the radius external to the superficial portion of the radial artery in the lower part of the forearm.

An incision about two inches long is made over the artery in the lower part of the front of the forearm, extending from the wrist upward. The artery is superficial here and can easily be felt. It is accompanied by two veins, which

should be dissected free as the tissues along these veins often contain small nerves. In the upper portion of the incision, the tendon of the brachioradialis will be to the outer side and the tendon of the flexor carpi radialis will be to the inner side. The artery is accompanied by a small branch of the musculo-cutaneous nerve, which should be avoided.

The ulnar artery is ligated in the lower part of the forearm on about the same level as the radial artery. It, too, is largely superficial at this point, being covered only by skin and fascia. Some cutaneous branches of the ulnar nerve are in front. *Internally* is the tendon of the flexor carpi ulnaris, and *externally,* to the radial side, are the tendons of the flexor sublimis digitorum. The lower portion of the artery corresponds to a line drawn from the anterior portion of the internal condyle of the humerus to the radial side of the pisiform bone. An incision is made about two inches long beginning at the pisiform bone and extending upward. The tendon of the flexor carpi ulnaris is retracted inward and if necessary the tendons of the flexor sublimis digitorum are retracted outward, though usually they are not in the way. The artery lies upon the flexor profundus digitorum and is closely surrounded by venæ comites. The ulnar nerve is in close relation to the inner side of the artery.

LIGATION OF THE ABDOMINAL AORTA

Ligation of the aorta in the abdomen is hardly a justifiable operation, in view of the fact that of the twenty cases that have been ligated all have proved fatal. One patient lived forty-eight days (Keen). It may be possible that in some cases with a markedly sacculated aneurism the neck of the aneurism itself could be clamped, or ligated, or a rubber tube might be sutured in between the ends of the resected aorta and held by flaps of fascia lata. Such procedures, however, are still in the experimental stage and would hardly be justified at present on the human body.

The technic of ligating the abdominal aorta in its lower portion would consist in making a median abdominal incision, in Trendelenburg position, and a close dissection of the aorta so as to prevent the inclusion of sympathetic nerves or lymphatic trunks.

LIGATION OF THE COMMON ILIAC ARTERY

The abdominal aorta bifurcates opposite the lower border of the left side of the fourth lumbar vertebra about one-half inch below and a little to the left of the umbilicus. Its two branches, the common iliacs, pass outward and bifurcate into the external and internal iliac arteries about opposite the upper border of the sacroiliac joint. On the right side, the common iliac artery near its termination is crossed by the ureter and is covered with peritoneum and subperitoneal fascia. *Behind* are the right common iliac vein, the termination of the left common iliac vein, and the beginning of the inferior vena cava. Still further posteriorly are the psoas magnus muscle with

the obturator nerve and the iliolumbar artery. *Externally* are the beginning of the lower vena cava, the end of the right common iliac vein, and the psoas magnus muscle. *Internally* are the right common iliac vein and the hypogastric plexus. On the left side, the common iliac artery has near its termination *in front* the ureter and the ovarian artery in the female, the termination of the inferior mesenteric artery, the sigmoid mesocolon, and the superior hemorrhoidal artery. *Posteriorly* are the lower part of the body of the fourth lumbar vertebra, the fifth lumbar vertebra and the intervertebral disc, the left common iliac vein, the psoas magnus muscle, obturator nerve and iliolumbar artery. *Externally* is the psoas muscle, and *internally* are the left common iliac vein, the hypogastric plexus and the middle sacral artery.

The right common iliac is about two inches long and the left about one and three-quarters. The arteries should be ligated as near their middle as possible. Formerly, when the danger of sepsis was great it was thought best never to open the peritoneum. In those days the extraperitoneal operation of Sir Astley Cooper was employed in order to avoid peritonitis. This danger does not now exist. The common iliacs, as well as the internal and external iliacs, can best be tied through an abdominal incision in the midline, extending from about the navel to the pubes. The patient should be put in the Trendelenburg position and the intestines packed away out of the pelvis, affording good exposure. The termination of the abdominal aorta is identified and the common iliacs are located. The peritoneum is incised over the middle of the common iliac and the ligature is passed from the side of the iliac vein. As elsewhere, there should always be two ligatures placed about a quarter of an inch to a half an inch from each other.

LIGATION OF THE INTERNAL ILIAC ARTERY

The internal iliac artery is about one and one-half inches in length and arises from the bifurcation of the common iliac opposite the upper part of the sacroiliac joint. The important relations are, *anteriorly* the ureter, *posteriorly* the external iliac vein, and *internally* the internal iliac vein. *Behind* is also the obturator nerve. The psoas muscle is *external*. This artery, which is frequently ligated to control bleeding in cancer of the uterus, is exposed by the same incision used for the common iliac. The bifurcation of the common iliac opposite the upper border of the sacroiliac joint should be located. The ureter is identified as it crosses about this region. On the left side the lower part of the sigmoid makes the operation slightly more complicated than on the right side. On the right side the peritoneum can be divided directly over the vessel. An incision about one and one-half inches long is made through the peritoneum, the ureter identified and retracted out of the way, and the bifurcation of the common iliac and its two branches, the external and internal iliacs, are thoroughly identified. The fascia over the internal iliac is incised and the ligatures are passed from without inward, hugging the artery close to avoid injury to the external iliac vein and also avoiding injuring the internal iliac

vein that lies close behind and to the internal surface of the artery. On the left side the ligation is carried out in the same manner as on the right, except that if the sigmoid is short and has a short mesentery it will be necessary to

Fig. 57.—Ligation of the internal iliac artery.

pull the sigmoid down to note the vessels in the mesentery so as to avoid them, and make an incision through the mesosigmoid (Fig. 57).

LIGATION OF THE EXTERNAL ILIAC ARTERY

The external iliac artery is three and one-half to four inches in length. It arises at the upper border of the sacroiliac joint, runs outward, and terminates beneath the lower border of Poupart's ligament. The external iliac vein lies to the inner side of the artery below and to the inner side and behind above. The genital branch of the genitocrural nerve lies in front of the artery over its lower third. It is crossed by the spermatic artery and vein in the male, and the ovarian artery and vein in the female, as well as by the vas deferens in the male near the termination of the artery. At this point also the deep epigastric artery, which is important for collateral circulation, lies *in front* of the vessel and adherent to the peritoneum as it courses forward and upward. *Behind* are the external iliac vein and the inner border of the psoas magnus muscle. *Externally* is the psoas magnus

muscle with the nerves it contains. The external iliac artery can be reached by the same incision by which the common and internal iliacs are reached, or if it is desired to ligate this artery nearer to Poupart's ligament, this can be done either by a muscle splitting incision or by the extraperitoneal operation in which an incision is made parallel to Poupart's ligament and about half an inch above it. The peritoneum is reached and stripped up and the external iliac artery is exposed. Care should be taken to preserve its branches, particularly the deep epigastric, for the collateral circulation. Although the peritoneum is not opened in the extraperitoneal operation, the Trendelenburg position is a great help. After the peritoneum is stripped up with dry gauze, the sheath of the external iliac is opened from the outer side to avoid the vein which is internal to the artery. Care is taken to avoid injury to the genitocrural nerve. A ligature is passed about one and one-half inches above Poupart's ligament.

LIGATION OF THE FEMORAL ARTERY

The femoral artery is a continuation of the external iliac and begins at the lower border of Poupart's ligament about half way between the anterior superior spine of the ilium and the symphysis pubis. It passes down the anterior and inner side of the thigh to the junction of the middle and lower thirds of the thigh, where it becomes the poplitcal. The superficial part lies in Scarpa's triangle, which is bound externally by the sartorious muscle and internally by the adductor longus with its base formed by Poupart's ligament. The apex of Scarpa's triangle is where the sartorius crosses the adductor longus. The lower third of the femoral artery passes through Hunter's canal, which is an aponeurotic channel that extends from the apex of Scarpa's triangle to the opening in the adductor magnus. The common femoral artery, which is that portion from the origin of the femoral to the origin of the profunda femoris, is about one and a half inches long. The important structures *in front* are the crural branch of the genitocrural nerve and the superficial circumflex iliac vein. *Behind* are the psoas and pectineus muscles; *externally* is the anterior crural nerve, and *internally* the femoral vein. The relations of the femoral artery from the origin of the profunda femoris to the apex of Scarpa's triangle are, *in front,* the crural branch of the genitocrural nerve and *behind,* the femoral vein, profunda vein, and profunda artery in the order named, then the pectineus muscle and the adductor longus. *Externally* are the branches of the anterior crural nerve, the long saphenous nerve and the nerve to the vastus internus, and *internally* is the femoral vein, which becomes posterior at the apex of the Scarpa's triangle. The third division of the femoral artery is that in Hunter's canal where it is deep. *Behind* is the femoral vein, which becomes slightly external at its lower portion; *behind* also, are the vastus internus and adductor muscles. *Externally* is the vastus internus and *internally* are the adductor longus above and the adductor magnus below.

The favorite point for ligation of the femoral is at the apex of Scarpa's triangle, which is called the operation of election. The apex of Scarpa's triangle is about three and one-half inches below Poupart's ligament and the profunda artery arises about one and a half inches below Poupart's ligament. At the apex of Scarpa's triangle the relation of the vessels from before backward is the femoral artery, femoral vein, profunda vein, profunda artery. The artery lies behind a line drawn from a point about midway between the anterior superior spine of the ilium and the symphysis pubis, to the tubercle of the inner condyle of the femur.

Ligation of the common femoral, or the femoral in its first portion, is considered dangerous because of the former frequency of secondary hemor-

Fig. 58.—Ligation of the right femoral artery just below Poupart's ligament.

rhage and because of the danger of gangrene. If ligation of the common femoral seems indicated it would probably be safer to ligate the external iliac.

The common femoral can be ligated by an incision about three inches long beginning just above Poupart's ligament and extending down in the line of the artery. The superficial circumflex iliac, superficial epigastric, and superficial external pudic vessels, should be avoided, also the crural branch of the genitocrural nerve, which is in front of and a little external to the artery. The anterior crural nerve lies further to the outer side of the artery and outside of the sheath. The ligature is passed from the inner side, avoiding injury to the femoral vein (Fig. 58). The common femoral artery can also be exposed by an incision parallel to Poupart's ligament and about one-half inch below it.

Ligation of the femoral at the point of eleetion, the apex of Searpa's triangle, is made through an incision three inches in length in the line of the the artery with the eenter of the ineision over the apex of Scarpa's triangle, whieh is about three and one-half inches below Poupart's ligament. First the inner margin of the sartorius muscle is identified and retracted outward, and then the tissues between the sartorius and the adduetor longus museles are disseeted. The long saphenous nerve is in front of the artery and is retraeted. The femoral vein is internal and posterior. The ligature should be passed from the inner side. The femoral artery is but seldom tied in Hunter's eanal, but may be ligated in this region by an incision about four inehes long over the line of the lower part of the artery, retraeting the sartorius musele inward as it forms the roof of Hunter's eanal. The spaee between the vastus internus and the adduetor magnus is disseeted and the internal saphenous nerve is found in the roof of Hunter's canal and retraeted out of the way.

LIGATION OF THE POPLITEAL ARTERY

The popliteal artery is a eontinuation of the femoral and extends from the opening in the adduetor magnus at the junction of the middle and lower thirds of the thigh downward and outward through the popliteal spaee to a point behind the knee joint and then directly downward to the lower border of the popliteus musele, where it divides into the anterior and posterior tibial arteries. The important struetures *in front* of the popliteal artery are the lower surfaee of the femur, the posterior ligament of the knee joint, the upper end of the tibia, and the popliteus musele. *Behind,* or superficially, are the inner head of the gastroenemius muscle, the aponeurotic areh of the soleus muscle and the popliteal vein, whieh lies behind the artery throughout its eourse but erosses obliquely from the outer to the inner side. The vein is elose to the artery. The internal popliteal nerve is posterior to the popliteal vein, and is first external and posterior, then erosses the popliteal vein and artery and assumes a posterior and internal relation at the end of the popliteal artery.

The artery is but seldom ligated, though it may be tied either in its upper or lower part. It may be approaehed at its upper portion from the inner aspeet of the thigh or from the inner part of the popliteal space behind. In its lower portion it is exposed from the lower part of the popliteal spaee behind. From the inner side of the thigh an incision is made about three and one-half inches long, beginning opposite the junetion of the middle and lower thirds of the thigh and running parallel with and immediately behind the tendon of the adduetor magnus. After exposing the anterior edge of the sartorious, whieh is retraeted backward, together with the internal saphenous vein, the tendon of the adduetor magnus is identified and drawn forward and the artery is sought between this tendon and the semimembranous, whieh is retraeted baekward. The popliteal vein lies next to the artery and behind. The popliteal

nerve is posterior to the vein. If ligation is made in the popliteal space it should be either at the upper or lower angle. At the upper angle, an incision is made about three and one-half inches in length with its center about the upper apex of the poplitcal space down to the middle of this space. The hamstring muscles are retracted to the outer and inner sides respectively and the popliteal nerve and vein are retracted out. In the lower portion of the popliteal space the incision is made so that its middle is about opposite the lower portion of the popliteal space. The nerve and vein there are retracted inward.

LIGATION OF THE ANTERIOR TIBIAL ARTERY

The anterior tibial artery is seldom ligated. It is one of the terminal branches of the popliteal artery and passes forward between the two heads of the tibialis posticus muscle and appears on the front part of the interosseous membrane between the tibia and fibula. It descends on the front part of this membrane, then on the tibia, and terminates at the front of the ankle joint by becoming the dorsalis pedis artery. The important structures *in front* of this artery are the anterior tibial nerve about its middle, the tibialis anticus and the extensor longus digitorum above and the extensor proprius hallucis below. *Externally* are the anterior tibial nerve above and below, the extensor longus digitorum above, the extensor proprius hallucis. *Internally* are the tibialis anticus above and the extensor proprius hallucis which crosses the artery below. The artery lies behind a line from the inner side of the head of the fibula to a point midway between the malleoli. The lower third is the most frequent site of ligation and the incision for this ligation should be made about three inches in length in the lower third of the leg. It is important to identify the tendon of the tibialis anticus and the tendon of the extensor proprius hallucis. The artery will be found between these two, the muscles and tendons lying on the anterior aspect of the tibia with the anterior tibial nerve on the outer side. It is accompanied by two venæ comites.

LIGATION OF THE DORSALIS PEDIS

This artery is a continuation of the anterior tibial artery and extends from the bend of the ankle on the tibial side of the foot to the apex of the first metatarsal space. The important relations *in front* are the inner tendons of the extensor brevis digitorum at the beginning of the artery, to the *outer side* are the tendons of the extensor longus digitorum and the anterior tibial nerve. To the *inner side* is the tendon of the extensor proprius hallucis. The artery lies behind a line drawn from the mid-point of a line connecting the two malleoli to the proximal end of the first metatarsal space.

An incision is made about two inches long in the line of the artery between the tendons of the extensor proprius hallucis on the inner side and the extensor longus digitorum on the outer.

LIGATION OF THE POSTERIOR TIBIAL ARTERY

This artery is the other and the larger terminal branch of the popliteal and extends from the lower border of the popliteal muscle down the back of the leg between the superficial and deep muscles, ending at a point midway between the tip of the internal malleolus and the os calcis. *In front* are the tibialis posticus and flexor longus digitorum. *Behind* are the superficial muscles of the posterior portion of the leg, the gastrocnemius and the soleus, and the deep intermuscular fascia. The posterior tibial nerve lies close to the artery and is first to the inner side, then crosses it posteriorly to the outer side, which is its relation in the lower two-thirds. The artery lies behind a line drawn from about two inches below the center of the popliteal space to midway between the tip of the internal malleolus and the apex of the heel.

To ligate the posterior tibial in its lower third, which is the usual place, an incision about two inches in length is made and should fall midway between the inner border of the tendo achillis and the inner border of the tibia. The posterior tibial nerve lies to the outer side. If the artery is to be ligated at its extremity an incision is made about one inch in length posterior to the inner malleolus. The internal saphenous vein should be retracted or divided and the annular ligament divided. The artery is found between the tendons of the flexor longus digitorum and the flexor longus hallucis, the nerve being to the outer or fibular side.

Many of the ligations detailed here are not often called for in modern surgery. Others, as in ligation of the tibial arteries in the upper portions and ligations of the pudic arteries, are, as Binnie says "more anatomical exercises than practical operations in surgery." They can be worked out on the cadaver by identifying the anatomical structures.

CHAPTER IX

ANEURISMS

An aneurism is a cavity that communicates with circulating arterial blood. The two general classifications of aneurisms are the true and the false. A false aneurism is formed from a hematoma and is equivalent to the later stages of the so-called pulsating hematoma. If in an injury to an artery, blood is poured out and a hematoma forms sufficient to prevent further bleeding, the cavity in the center of the hematoma and communicating with the artery, may become lined with endothelium and the tissues in the neighborhood form a connective tissue sac. This is a typical false aneurism. A true aneurism is not a tumor in the ordinarily accepted meaning, for a tumor is new tissue that has sprung from a matrix of cells. A true aneurism is a dilatation of a previously existing vessel and is not in any real sense new tissue, but merely an increase of previously existing tissue.

Surgical operations for aneurism include various methods, such as wiring, electric puncture, direct and indirect compression, ligature, incision, obliteration of the sac, and excision of the sac alone or combined with the substitution of a segment of vein.

We will first consider the methods particularly applicable to aneurisms of the aorta as these aneurisms cannot be reached by the direct attacks employed elsewhere. "Needling" was advised by McEwen in 1890. The method is quite uncertain, though McEwen reports satisfactory results. It consists of the introduction into the sac of a long, fine needle which scratches thoroughly all of the lining of the sac. This is followed by the deposition of fibrin and, according to McEwen, the fibrin thrown down after needling is peculiarly firm. The operation, however, has not been adopted by many surgeons.

The introduction of wire into an aneurism was first done by Moore, of London, in 1864. It has been widely used, particularly in connection with the modification by Corradi, in 1879, of passing a galvanic current through the wire. Finney, of Baltimore, has had very favorable experience with this method and reports several cases much benefited and some apparently cured. Finney recommends the wire originally proposed by Hunner, which consists of a silver alloy containing seventy-five parts of copper to 1,000 parts of silver. This wire is wound tightly on a wooden spool, in order to make it coil, and should be of such size as will readily pass through the ordinary aspirating needle. The needle is insulated with a coat of the best French lacquer to within a short distance of its point. This prevents an electrolytic burn that might be the site of a subsequent hemorrhage. Under local anesthetic the

needle is inserted into the skin which is drawn to one side so that when the needle is removed the opening in the skin is not opposite the opening in the sac. Finney uses ten feet of wire, claiming that a larger amount may prevent the contraction of the clot in the sac. The needle is inserted slowly until arterial blood appears in spurts through the needle. The end of the wire should be engaged in the lumen of the needle before the needle is inserted. At first a small amount of blood will spurt around the wire. The wire is then threaded through into the aneurism, care being taken that no portion of the needle that is not protected with lacquer comes in contact with the skin. The positive pole of a galvanic battery is then connected with the wire, a negative pole being placed at the patient's back. This is important as the negative pole to the wire will cause disorganization of the clot rather than hasten its formation. The current, according to Finney, should not be greater than seventy-five m.a., but should be continued at least an hour. In abdominal aneurisms, the aneurism should, of course, be fully exposed and the viscera packed away. This is done under local anesthesia. After the current has been passed at least an hour in thoracic aneurisms the needle is slowly removed, twisting it somewhat in order to withdraw it gradually. The skin is depressed around the wire and the wire cut flush with the skin. The skin is then pinched up and the end of the wire will disappear under the skin. If the skin has originally been drawn to one side, there is no direct communication between the hole in the skin and that in the sac.

Aneurisms of the aorta should first be carefully studied with the x-ray before being subjected to wiring. A diffuse dilatation or a spindle-shaped aneurism obviously cannot be treated by such a measure, which should be reserved for the distinctly sacculated type. Attempts have been made to cure aneurisms of the abdominal aorta by ligature, and the abdominal aorta has so far been ligated for various causes, chiefly for aneurism, about twenty times with fatal result in each case. In some abdominal aneurisms the metal band introduced by Halsted seems indicated. By this means the circulation through the aneurism can be greatly diminished though not entirely obliterated, and after collateral circulation has been sufficiently established the band may be removed and a ligature applied. If, however, important arteries, such as the renal or the celiac axis, arise from a prominent portion of the sac, the case would seem utterly hopeless, as any method that obliterates the sac would, of course, occlude these arteries, with the necessity of a fatal result.

This principle of the gradual obliteration of arteries has added greatly to the effectiveness of treatment of certain types of aneurisms. It may be sometimes employed as a direct cure but its chief value lies in the development of collateral circulation by the diminution of the arterial lumen without entirely occluding it. This was first worked out by Halsted[1] who made use of aluminum bands with smooth edges. These bands were placed around the artery and curled into position by a special device. Later the bands were modified by Matas, who used them in a long ribbon in the form of an aneu-

[1]Jour. Exper. Med., 1901, xi.

rism needle. The bands may be molded and placed with the fingers. They vary in width from $\frac{3}{16}$ to $\frac{5}{16}$ of an inch and are about as thick as a sheet metal gauge No. 23, which is 0.6 mm. in thickness.

In some interesting experimental work Halsted[2] has found that there is frequently dilatation of the vessel on the distal side of the band which appears to be difficult to explain, but which he thinks is due to a form of eddy or whirl in the partially obstructed current.

In the treatment of aneurisms of the extremities it is important to develop the collateral circulation to as great an extent as possible, before any attempt is made to excise the aneurism or to close the sac. This may be done by hot packs around the limb several times a day, extending over a period of a half to one hour at a time. Digital pressure on the artery or pressure by a special apparatus may be used. The circulation should be tested, as suggested by Matas, by applying a firm Esmarch bandage from the extremity of the limb to the trunk. The main artery is then compressed, the Esmarch removed, and note made of the returning circulation which is carried on collaterally. In the thigh a hyperemic flush extends quickly to the knee, but may go much more slowly or not at all to the foot. If the flush does not reach the ankle, operation should be postponed and treatment with hot packs or local compressions of the artery is instituted until collateral circulation has been satisfactorily established. The most serious objection to this method of testing is that it is inapplicable in negroes or people with a very dark skin.

Compression is recognized as one of the oldest methods of treating aneurisms. While various appliances have been used they have not been quite so satisfactory as digital compression properly applied. It requires a number of assistants who can relieve each other from time to time. The skin where pressure is to be made is covered with French chalk. Each assistant is instructed as to the amount of pressure necessary, the direction in which it must be made, and the manner of changing from one assistant to another, so at no time during the treatment is the artery without compression at or about the same point. The femoral artery below Poupart's ligament is the most favorable location for digital compression. Each sitting lasts four hours. Sometimes one sitting will result in a cure, but usually ten or even twenty sittings are necessary. This method is unsatisfactory and uncertain in comparison with modern methods and is by no means free from danger of gangrene.

The elastic compression of Reid consists of bandaging the limb by an elastic bandage up to the aneurism and then skipping the aneurism, but bandaging the limb above it. In this way the blood is shut off above and below the aneurism and clotting is often produced. The bandage, however, should not be left on longer than an hour and a half and in elderly people half this time is much safer. According to Delbet, this treatment leads to gangrene twice as often as digital compression.

Extreme flexion has been suggested by a number of surgeons, but is often

[2]Surg., Gynec. & Obst., Dec., 1918, pp. 547-554.

called the method of Hart. It is applicable in the treatment of aneurisms developing in the popliteal region, in the groin or in the elbow. It consists of forced flexion which must be maintained about fourteen days. It is exceedingly painful and cures only about one-third of the cases.

The classical methods of using the ligature for the cure of aneurism have been long established. The operation of Antyllus has been practiced since the second century of the Christian era, and has on the whole given exceedingly satisfactory results. It consists of ligating the artery close to the aneurism, both centrally and distally, and then incising the sac (Fig. 59). In

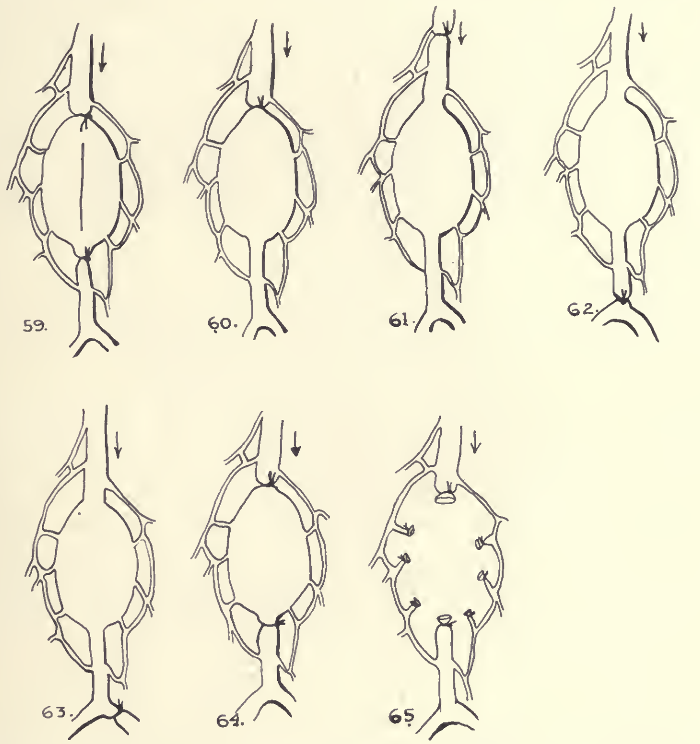

Fig. 59.—The operation of Antyllus for aneurism.
Fig. 60.—The operation of Anel for aneurism.
Fig. 61.—The operation of John Hunter.
Fig. 62.—The operation of Brasdor.
Fig. 63.—The operation of Wardrop.
Fig. 64.—The operation of Pasquin.
Fig. 65.—The operation of Purmann.

preantiseptic days the suppuration following this method made the mortality high, but in spite of that the percentage of cures has been gratifying.

Anel's method, first used in 1710, consists in ligating the artery centrally but as close as possible to the sac (Fig. 60). In preantiseptic days where suppuration was a rule, secondary hemorrhage was frequent. It was thought this was partly due to the fact that the artery near the sac was very likely to be diseased; so John Hunter established a new principle of ligating, in 1785, by applying the ligature centrally, but at some distance from the aneurism (Fig. 61). In this method branches are given off from the main artery between the ligature and the aneurism. It is still used to some extent but has many

disadvantages. First of all, it assumes that the artery is less diseased at a distance from the aneurism than close to it. This is by no means always true. Secondly, the liability to gangrene is increased, because if the sac is occluded by a clot there will be two obstructions to the current instead of one, the obstruction at the site of ligature and another further down where the aneurism is closed by clots. Thus the collateral circulation between the ligature and the sac is greatly diminished and the blood has to pass through two sets of collateral branches, one from above the ligature to vessels between the ligature and the aneurism, and one from this set to the vessel below the aneurism, in order to maintain the nutrition of the limb. If, however, the collateral circulation is free, the aneurism may not be sufficiently occluded by clots and no cure will result. With modern technic and an absorbable ligature the operation of Anel is far superior to that of Hunter.

Brasdor instituted the method of distal ligation in 1798, ligating distally the main trunk (Fig. 62). Wardrop, in 1825, applied ligatures distally to one or two of the main branches of the artery (Fig. 63). This was used in aneurism of the innominate where the carotid artery was often tied. The application of a ligature immediately above and below without opening the sac is called Pasquin's method and was first applied in 1812 (Fig. 64).

Ligation on each end and close to the aneurism with extirpation of the sac has been known as the operation of Purmann, who used it in 1680 (Fig. 65). It is necessary to have complete hemostasis either by the tourniquet, or by clamping, or by temporary ligatures. Often large collateral vessels open into the sac, so a central ligature may not completely control the hemorrhage. It is also important to preserve the vein in extirpating the sac, for if the vein is injured or ligated, gangrene is more likely to occur. Bleeding is controlled by sutures which do not go deeper than necessary, as packing, if depended upon to stop bleeding may also interfere with the collateral circulation.

Ligation with extirpation of the sac compares very favorably in results with simple ligature, as it has a somewhat lower mortality in a large number of cases than the Hunterian method of ligation, and the dangers of gangrene are about the same.

The greatest improvement in the treatment of aneurisms in modern times is the operation of Matas, which was first performed by him in 1888, on a brachial aneurism that had not been cured by either proximal or distal ligature. The operation is subdivided into three different types, though the principle is the same in each. The fact that extirpation of the sac, and the Syme operation in which the artery is ligated within the sac, are followed by a comparatively low mortality and a high rate of cure makes it evident that the nearer the ligature is placed toward the sac, other things being equal, the better the results will be. The objections to extirpation are obvious. The operation is not only difficult, involving the enucleation of considerable tissue, but there is a likelihood of injury to the veins or nerves,

and, most important of all, the tissues enucleated often carry collateral vessels that are highly important.

The three types of the operation of Matas are obliterative endo-aneurismorrhaphy, restorative endo-aneurismorrhaphy, and reconstructive endo-aneurismorrhaphy (Figs. 66, 67 and 68). The obliterative type may be used in any form of aneurism, but it was particularly designed for cases in which there are two openings in the sac some distance apart, or when the sac is peculiarly friable. Hemostasis is obtained by a tourniquet if possible, or if this is impracticable by the clamps devised by Crile or Matas, or by the clamps that I devised for lateral suture of blood vessels (p. 136). These clamps are placed on the artery and its main branches both above and below the sac. The sac should not be dissected out, so whenever a tourniquet can be used instead

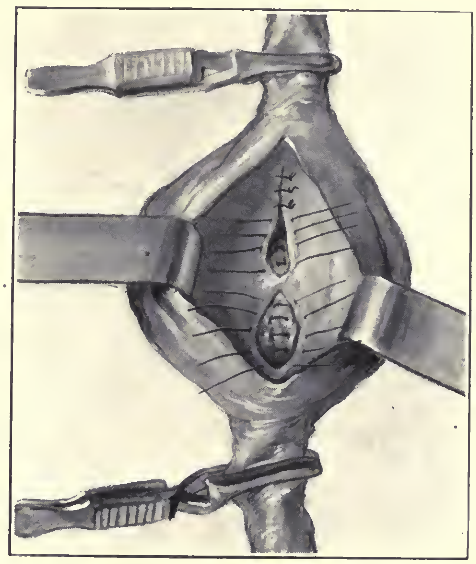

Fig. 66.—Obliterative endo-aneurismorrhaphy of Matas.

of a clamp it is always preferred. By bearing in mind the principle on which the operation is founded—conserving every possible collateral branch in the sac and surrounding tissues—the operation can be carried out more intelligently. After the tourniquet has been applied an ample incision is made through the skin over the aneurism. If it is impossible to place the tourniquet, the vessel is exposed centrally and peripherally a few inches from the aneurism and clamps applied, as mentioned above. The sac is then opened without separating it from the surrounding tissue and clots are thoroughly removed. A suture of chromic or tanned catgut in a small, round, curved needle is passed around the openings of the artery taking care to tie the openings snugly but not using too much force as the suture may cut out. The sac is searched for other openings of collateral arteries or branches and these are also closed. The tourniquet or clamp is released to see if the bleeding in the sac is controlled and is immediately reapplied. Then the sac is obliterated by rows

of sutures of chromic or tanned catgut, the first row running preferably from one arterial opening to another. After this has been finished another row is placed. In intraperitoneal aneurisms the peritoneum is sutured so as to cover the raw surface. The manner of treating the sac after the two tiers of obliterative sutures have been placed, depends largely upon the condition of the sac and must of necessity be left to the judgment of the surgeon, as in plastic work. The essential features are to close the arterial openings into the sac and to place at least two rows of continuous chromic or tanned catgut, obliterating the sac as far as possible from one of the main arterial openings to the other. After this, the recesses of the sac are folded upon themselves if possible, or sutures are carried through a double thickness of the sac and tied in the margin of the wound, or else brought out through the skin. All dead spaces should be obliterated and the wound closed without

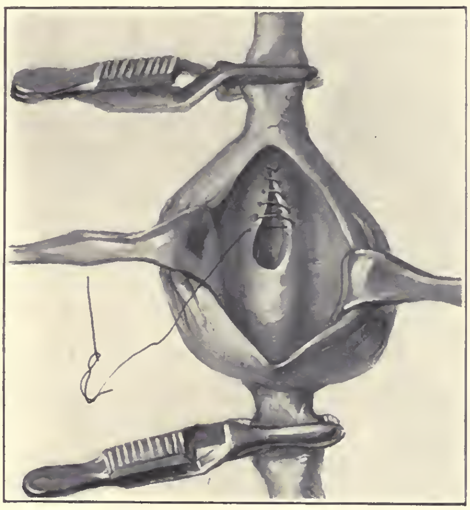

Fig. 67.—Restorative endo-aneurismorrhaphy of Matas.

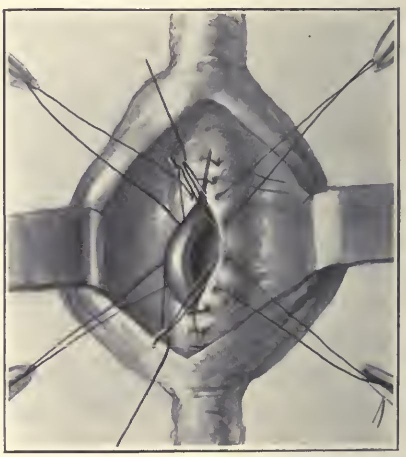

Fig. 68.—Reconstructive endo-aneurismorrhaphy of Matas.

drainage. The blood current is gradually turned on before the skin is sutured and the infolded sac is pressed upon. Usually there is but little, if any oozing, though if it is marked the tourniquet should be reapplied and the leak stopped by additional sutures. The smooth membrane lining the inside of the sac is vascular endothelium and requires no freshening or injury to heal, but merely snug approximation just as the peritoneum requires.

Restorative endo-aneurismorrhaphy (Fig. 67) is applicable when the sac is tough and resistant and when there is only one opening. In other words, when the aneurism springs from one side of the artery and the whole of the artery's circumference is not involved. This does not occur very frequently. In such cases the opening is sutured either by surrounding it with a purse-string suture or by whipping it over with a continuous stitch. The rest of the procedure is identical with the obliterative method.

Reconstructive endo-aneurismorrhaphy (Fig. 68) is recommended by Matas in cases in which the two openings are close together, where there is but little atheroma, and where the sac is tough and holds the sutures well. The sac is cleaned of clots and washed out with salt solution. Matas recommends that a soft rubber catheter, well anointed with vaseline and which fits snugly into the arterial opening, be inserted and interrupted sutures of chromic catgut be placed at close intervals over the catheter. After the sutures have been placed the catheter is withdrawn and the sutures are tied snugly. The rest of the sac is obliterated as in the other methods.

In all of these methods care should be taken not to take a deeper bite with the suture than is necessary to secure a firm hold. The needle may wound the accompanying vein or nerve, or if inserted too deeply, may occlude some collateral vessel.

Reconstructive endo-aneurismorrhaphy probably sooner or later either becomes obliterative or fails to cure. The fact that, in several instances, thrombi which formed after the reconstructive operation were later dislodged and acted as emboli, is also a serious objection to this method. In the light of modern blood vessel suturing, we can hardly expect the reconstructed artery to remain patent. In experimental work under the best conditions with comparatively healthy blood vessels and using the finest sutures of silk and the finest needles, it is impossible to avoid occlusion of the artery in a considerable number of cases even after some experience in this work. We can hardly expect, then, that suturing with comparatively coarse needles and catgut in diseased tissue will produce a permanently patent artery. If there is merely a small opening the restorative method may be indicated, but the eventual result will probably be better if the obliterative method is always used instead of the reconstructive type. The only advantage in the reconstructive operation is that for a short time blood flows through its natural channel and the consequent strain upon collateral circulation will not be so great. This advantage, however, seems offset by the dangers of sudden emboli from the breaking loose of a thrombus, by the fact that sooner or later the channel in all probability becomes obliterated, and by the further fact that recurrences are much more common after the reconstructive than after the obliterative method. Matas has collected statistics which prove beyond doubt that wherever endoaneurismorrhaphy can be applied it is far more satisfactory than either ligature or extirpation; not only is the mortality rate less but gangrene is exceedingly rare.

Extirpation of aneurisms has been done with direct suture of the artery by the end-to-end method. This is only applicable where the site of the aneurism involves a very short section of the artery and where the ends of the artery are comparatively healthy. It has been done by Lexer, Stich, and Enderlen in poplitcal aneurisms. The limb is flexed and kept in this position for several weeks by plaster of Paris. After the sixth week the knee may be gradually extended. This method has, of course, a very limited application.

The ideal treatment of aneurism is to excise the sac and at the same time to restore the arterial channel. This may be accomplished by substituting a segment of vein. The vein that accompanies the artery has been used, though it would be much better to utilize some other vein. Obviously, when the direct circulation is deficient on account of the aneurism, and collateral circulation is poor, closing the main artery by ligature or obliteration of the sac—even by the method of Matas—is fraught with great danger and the indications are, if possible, to reestablish the circulation by the ideal method. In a diseased artery, arterial sutures would not seem to be satisfactory, and it is certainly more desirable to suture healthy arteries as in traumatic aneurisms than the diseased vessels of spontaneous aneurisms. However, the brilliant case of Lexer, already referred to (p. 75), in which he excised an aneurism involving a portion of the external iliac and femoral arteries and sutured into the defect a segment of the saphenous vein with perfect success, shows the great possibilities of this operation. Bernheim, of Baltimore, has successfully excised a popliteal aneurism and sutured in a segment of vein.

If success is to be attained in suturing diseased arteries the best possible technic should be used. As already pointed out, it is not likely that reconstructive endo-aneurismorrhaphy, in which comparatively coarse needles and catgut are used, will result in a permanently open channel. Certainly in experimental work such technic would invariably be followed by thrombosis in healthy arteries, and in diseased arteries we have no right to expect better results. It is practically impossible, however, to use the technic of arterial suturing in the bottom of a sac where the tension on the stitches must be considerable, but after the sac is excised a segment of vein can be sutured to the ends of the artery with the regular technic for end-to-end suture. While there is some danger of the segment becoming occluded by thrombus, it seems for the reasons mentioned that if it is necessary to reestablish the current of the blood, it should be done not by the reconstructive method of Matas, but by excision of the sac and suturing into the defect a segment of vein. Reversing the circulation and then excising the aneurism has been tried. This has none of the advantages of transplantation of a venous segment.

OPERATION ON ANEURISM OF SPECIAL ARTERIES

Aneurisms of the thoracic aorta are by far the most frequent aneurisms, which would naturally be expected from the strain to which this great vessel is subject. The proper treatment is medical treatment though in sacculated thoracic aneurisms the Moore-Corradi method may be used. The technic employed by Finney is probably the most satisfactory (pp. 118, 119). A thorough examination by x-ray should be made before this operation is attempted. The average course of a thoracic aneurism is a little more than a year. There has been one effort to cure a thoracic aneurism by ligating the aorta. This was done by Guinard, of Paris, in 1904, the chest being opened posteriorly by an osteoplastic flap and a ligature placed on the thoracic aorta

just below the end of the arch. When the ligature was tightened, pulsation in the femoral artery stopped and the lower part of the body became pale and cold, but in a few minutes the circulation was reestablished through the intercostal and other vessels. However, the blood pressure through the collateral circulation was not sufficient for the renal arteries and the patient died.

Aneurisms of the abdominal aorta are scarcely amenable to other direct treatment than the Moore-Corradi method. If the aneurism is above the renal arteries or involves the mesenteric, its obliteration will necessarily result fatally on account of interference with the function of the kidneys or from gangrene of the intestines. Below the inferior mesenteric artery, the outlook seems more hopeful, but the results are practically equally as disastrous. Of about twenty cases of ligature of the abdominal aorta none has been successful. The strain thrown upon the heart by the increased blood pressure after such a ligature is enormous and this high pressure and a competent heart are essential to the proper establishment of collateral circulation. Most of these patients have hearts that are far from competent, and even in healthy animals ligation of the abdominal aorta usually results in a cardiac death. Even if the heart should survive the strain, which it does not do in the vast majority of cases, there is still the risk of hemorrhage and the possibility of sepsis and shock. The iliac arteries have been ligated for abdominal aneurisms, following the principle of Brasdor and Wardrop, but this too has proved fatal. Various methods of compression have been advocated and even endo-aneurismorrhaphy has been tried, but unsuccessfully. The aluminum band of Halsted or of Matas which would produce a partial but not a complete occlusion of the aorta seems to offer the most satisfactory method of treatment, if wiring and galvanism are not indicated. If this did not cure the aneurism after a few weeks, the collateral circulation it encouraged might justify ligation of the aorta. Various problems, particularly the strain upon the heart, render treatment of aneurisms of the aorta a very unsatisfactory procedure. Experimentally, a portion of the abdominal aorta has been resected and a tube sutured into the defect (p. 90).

Aneurisms of the innominate seem to offer a field for the Moore-Corradi method, though they have been treated successfully by ligatures. Apparently the best operation is distal ligation after Wardrop or Brasdor. Ligation of the right common carotid and the right subclavian is done during the same operation, tying the carotid first to avoid the possibility of a cerebral embolus.

Aneurisms of the external carotid are quite rare, but occasionally occur. Treatment by ligatures, placing the ligatures as far as possible from the bifurcation of the common carotid, may be employed. The injection into the external carotid of boiling water after the suggestion of Wyeth might be indicated, as the collateral circulation with the carotid of the other side is so free as to render simple proximal ligation much less likely to cure here than in most other arteries. Aneurisms of the common carotid or of the internal carotid are of grave significance because of the disastrous effect on the brain that often follows when these arteries are tied. The danger of ligation of the

common carotid increases enormously after forty years of age and is due to the danger of a diminished blood supply to the brain. In the young with elastic arteries ligation of the common carotid is comparatively free from danger, but after forty years of age, and particularly in the presence of arteriosclerosis, the occurrence of cerebral symptoms, from the inability of other arteries to dilate sufficiently, is frequent. The operative measures that have been used are the classical methods of ligation, though of these extirpation with the double ligature has proved most successful. Proximal ligature is particularly liable to cause thrombi in the sac with the possibility of a piece of thrombus becoming loose and causing an embolus in the brain. This, of course, is in addition to the danger of cerebral symptoms from the mere occlusion of the artery. Distal ligation or extirpation to a large extent avoids the danger of embolus.

It has been found that when cerebral symptoms occur, serious danger may often be avoided if the channel of the artery can be re-established within a few hours after occlusion. The problem in connection with the carotid artery is different from that in other parts of the body, not only because of the immediate danger to life by impairing the blood supply to the brain, but because we have a method of determining from the patient's sensations and symptoms whether occlusion of the artery is safe. Before applying a ligature to the carotid, except in cases of grave necessity, the common carotid should be exposed under local anesthesia and gradually occluded, preferably by a rubber covered Crile clamp. If this is followed by cerebral symptoms of a psychic nature, by paralysis or convulsions, the artery should be opened at once. If no immediate symptoms occur, the clamp may be left on for forty-eight hours and then a ligature applied to occlude the artery with comparative safety. However, cerebral symptoms sometimes appear after several days, though they are usually manifest within twenty-four hours after occlusion of the artery. If complete closure is not possible the metal band of Halsted may be rolled around the artery in such a manner as partially to occlude it. If this is sufficient to cure the aneurism no further treatment is necessary; but if not, the band may be left in place for one or two weeks until the other arteries have taken up the circulation, and then a ligature can be applied. If even a partial occlusion is not borne the outlook is almost hopeless, though the possibility of excision and the substitution of a segment of vein should be considered.

Subclavian aneurisms have been subjected to numerous methods of treatment including the intrasaccular ligation of Syme. They have been treated by ligature, both distal and proximal, and the innominate artery has also been ligated in efforts to cure. The results have usually been unsuccessful, the mortality being large, though since 1890, the mortality has fallen from about eighty per cent in preantiseptic days to twenty-two per cent. The metal band may also be used here. Excision of the sac seems to have been followed by quite satisfactory results as compared with other methods of treatment.

Endo-aneurismorrhaphy has been attempted, though in not a great number of cases, and the results usually have been satisfactory.

Axillary aneurisms may be treated by ligature, by band, or by the operation of Matas. In certain cases where the circulation can be controlled, excision of the aneurism with the substitution of a piece of vein may be considered. This has been done by Lexer and while the patient died from gangrene of the limb it was found that the occlusion from thrombus occurred where the clamp was placed, the transplanted section of vein being patent and in good condition.

The treatment of aneurism of the iliac arteries is subject to somewhat the same objections as the treatment of aneurism of the aorta, for ligation of these large arteries produces great strain upon the heart. The intrasaccular method of Matas offers in certain cases excellent results, though hemostasis may be difficult or impossible except by compression of the aorta.

The aluminum metal band is particularly applicable in aneurisms of the iliac arteries. By this means the current can be reduced to a minimum without being obliterated and the danger of gangrene of the extremity is greatly lessened. At a second operation after a few weeks the artery can be permanently occluded near the site of the band by ligatures. This principle is applicable to aneurisms anywhere when there is a reasonable doubt that the collateral circulation will not be sufficient if the artery is entirely occluded by a ligature or if the endo-aneurismorrhaphy of Matas is contraindicated.

The common and external iliac arteries may be regarded as practically an extension of the aorta. Aneurisms affecting all of the iliac arteries are lined in front with peritoneum. They tend to dilate quickly as there is but little resistance in front and they rupture easily for the same reason. When rupture occurs it is usually immediately fatal, though occasionally the blood may form a large hematoma under the peritoneum. The treatment of aneurisms of the iliac arteries may be some form of ligature, a partial constriction by the aluminum band, or endo-aneurismorrhaphy. Digital compression is not practical, though it may be tried by opening the abdomen and compressing the common iliac or the aorta. In extirpation or in endo-aneurismorrhaphy, temporary hemostasis can be effected by digital pressure on the abdominal aorta, or else upon the trunk of the common iliac near the bifurcation. Even pressure upon the aorta may not give an entirely dry field as some blood comes through the distal end of the deep epigastric artery. Pressure upon the iliac is often unsatisfactory because of the free anastomosis with the internal iliac of the other side. Aneurisms of the external iliac have occasionally been treated by digital compression. Compression of the abdominal aorta through the abdominal wall is possible in thin patients, but is best done within the abdomen. In a thin patient the method of Momburg, constricting the abdomen with a rubber tube, has been tried. This will give a dry field, but there is always danger from an abdominal tourniquet, such as injury to the intestines, though the originator of this method claims otherwise. The treatment of aneurism of the iliacs has been largely by the ligature.

Double ligation, distal and proximal, with extirpation has given satisfactory results. The iliacs should be ligated intraperitoneally. The older method of stripping up the peritoneum and making an extensive raw surface is unnecessary. The patient may be put in the Trendelenburg position with the intestines packed off, and ligation of either the common iliac or its two branches can be readily done. Endo-aneurismorrhaphy has been tried in a few cases with satisfactory results. Ligation of the common iliac carries a heavy mortality rate. Matas says that in modern times, since 1880, the death rate is nearly fifty per cent. This high mortality rate, as explained by Halsted in an article on aneurisms of the iliac, is largely due to complications and would probably now be considerably lower. The fact, however, that the mortality from simple ligation is much higher than from extirpation or endo-aneurismorrhaphy should cause the later method to be employed wherever possible.

Aneurisms of the upper femoral artery require a similar hemostasis to aneurisms of the iliac, as it is impractical to place a tourniquet at this level. The external iliac gives off but few branches whereas the upper part of the femoral has a very abundant collateral circulation. For this reason in pre-antiseptic days ligation of the femoral just below Poupart's ligament was avoided whenever possible. The collateral circulation is so free at this point that formation of a thrombus is prevented or retarded and as suppuration usually took place in those days, secondary hemorrhage would occur in about half of all cases; consequently, the external iliac whose branches are few could be ligated much more safely. With absorbable ligatures and careful asepsis, these objections are no longer so serious.

In aneurisms of the upper or common femoral it is exceedingly difficult to obtain even temporary hemostasis unless the same measures are employed as in aneurisms of the iliac; that is, direct compression of the abdominal aorta or the common iliac after opening the abdomen. The communications of the profunda, which is almost always in the sac of an aneurism in this region, together with other collateral branches make the field very vascular. The necessity for controlling bleeding by intraabdominal pressure on the iliac in such cases should be seriously considered whenever it is desired to open the sac of an upper femoral aneurism.

Aneurism of the branches of the internal iliac practically always occurs either outside of the pelvis or else partly without and partly within the pelvis. It usually involves the sciatic or the gluteal arteries. Formerly, the most satisfactory treatment was the method of Antyllus, in which the vessel is ligated both proximally and distally and the sac incised. The better method is endo-aneurismorrhaphy with either temporary or permanent closure of the internal iliac by ligature. When the aneurism begins in the pelvis, which is very unusual, merely ligating the internal iliac may be all that is necessary.

Aneurism of the lower femoral can be treated most satisfactorily by endo-aneurismorrhaphy and here as elsewhere the obliterative operation is better than the reconstructive. If after testing the collateral circulation it appears

deficient and the patient's condition is otherwise good, the possibility of excising the aneurism and substituting a piece of the saphenous vein from the other leg should be considered. The aluminum band may be used with advantage before resorting to a more radical operation.

Popliteal aneurisms may involve the whole of the artery in the later stages, but in the early stages they are often of the saccular form in which a very small portion of the artery is affected. In several instances the aneurism has been excised and the ends of the artery were united by end-to-end suture. Aneurisms arising from the upper part of the popliteal are much less likely to cause gangrene than those from the lower portion of this artery, because most of the collateral circulation from the articular, azygos, and muscular branches opens into the lower portion of the popliteal. The former treatment of popliteal aneurism was peculiarly unsuccessful. Various meth-

Fig. 69.—Traumatic aneurism of the temporal artery.

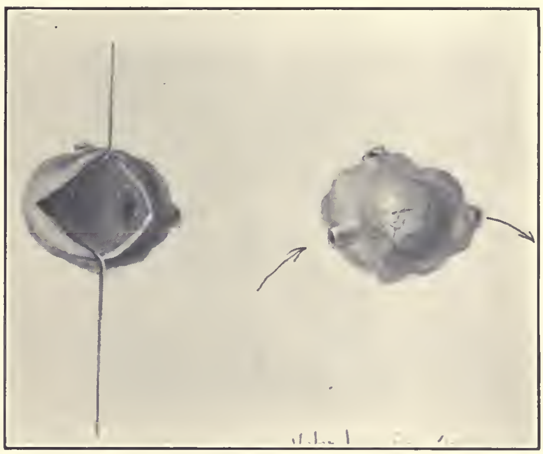

Fig. 70.—The excised sac of the traumatic aneurism shown in Fig. 69. Note the afferent and efferent vessels.

ods of ligation have been used. As popliteal aneurisms comprise about one-third of all aneurisms, excepting those of the aorta, the clinical material for operative treatment of aneurism has been largely drawn from those of the popliteal type. Of the various methods of ligation the Hunterian has been the most popular, but the radical operation consisting either of extirpation of the sac or the operation of Antyllus, a distal and a proximal ligature and incision of the sac, has given better results. Endo-aneurismorrhaphy is peculiarly applicable to popliteal aneurisms and in sixty-two cases there was only one death which was due to tetanus and two cases of gangrene, and in both of these instances the vein that accompanied the artery was injured and had to be ligated. This, of course, was not a fault of the method. In all others recovery occurred. There was secondary hemorrhage and relapse in four cases, but in these the reconstructive method was used, proving the wisdom of adopting the obliterative type of endo-aneurismorrhaphy.

Aneurisms of the smaller arteries, such as the radial, ulnar or tibial ar-

teries are satisfactorily treated by extirpation of the aneurismal sac with double ligation of the artery. The circulation from the companion artery is usually so abundant and the control of hemorrhage by a tourniquet during the operation is so satisfactory that this method offers not only radical but safe treatment.

As a result of experience in the World War some surgeons have begun to regard the direct suturing of the aneurismal vessel as a more satisfactory operation than ligation. Thus von Haberer[3] has reported forty-two operations for aneurism in which he did ligation and extirpation of the sac in twenty-nine cases and sutured the artery in thirteen cases. He concludes that suture is the operation of choice whenever it can be performed. In many instances it is impossible to suture. Five of Haberer's cases were lateral suture, one of these being on the common carotid and two on the subclavian arteries. In seven cases there was resection and end-to-end suture, four of these being in the femoral artery, one in the brachial and two in the subclavian.

Fig. 71.—The second case of traumatic aneurism of the temporal artery.

Fig. 72.—Drawing of the excised sac shown in Fig. 71.

Of the twenty-nine cases in which ligation was done amputation was necessary in two patients and one died of hemorrhage from erosion. All of the thirteen cases in which the artery was sutured recovered without complication.

The aneurisms which Haberer treated resulted from wounds. Here, of course, the arteries are supposed to be healthy and suturing in all probability can be carried out with much greater prospect of success than in the so-called idiopathic aneurisms that result from disease of the vessel wall. Then, too, the traumatic aneurisms encountered in military surgery are in all probability the late results of a pulsating hematoma or in reality are false aneurisms.

There are a few cases on record of aneurisms of the temporal artery which follows an injury to the head. They are small pulsating tumors, and have all the characteristics of a miniature aneurism. They are best treated by excision and ligation of the arteries on both sides[4] (Figs. 69, 70, 71 and 72).

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[3]Wien. klin. Wchnschr, 1915, xxviii, 435, 471; Abstracts of War Surgery, St. Louis, 1918, C. V. Mosby Co., p. 273.

[4]Horsley, J. Shelton: Traumatic Aneurism of the Temporal Artery, Ann. Surg., March, 1917, pp. 317-320.

CHAPTER X

ARTERIOVENOUS ANEURISM

An arteriovenous aneurism is a lesion in which there is a communication between an artery and a vein. The vein may be a sinus in the dura mater. There are two forms of this aneurism; varicose aneurism, in which the communication between the artery and the vein is indirect and a sac exists between the two vessels; and aneurismal varix, in which the blood flows directly through the opening from the artery into the vein. There are many combinations such as a sac in the artery opposite the opening into the vein or there may be two sacs, one in the artery opposite the opening and one between the artery and the vein. The vein becomes dilated, particularly the proximal vein, unless the parts around it form a firm support. Dilatation of the vein is called varicose aneurism by dilatation. Secondary arteriovenous aneurisms are found in the region of the heart and around the aorta where a preexisting aneurism has ruptured into a vein. The most frequent cause of arteriovenous aneurism is trauma, a gunshot wound being the common form of traumatism. The modern bullet which makes a small puncture is very likely to cause an injury of this nature. Formerly, when bleeding was in vogue, arteriovenous aneurism at the elbow with a communication between the brachial or the ulnar artery and a vein, was comparatively frequent. Fractures, stabs, or indirect injuries may also result in arteriovenous aneurisms, but occasionally it occurs spontaneously, which is rare and is probably due to some degeneration in the wall of the artery that permits perforation at this point. The distal portion of the artery becomes contracted and narrow since it is subject to less than its normal pressure as a portion of the blood intended for it is delivered to the vein. The central segment of the artery, however, is much dilated. This was supposed at one time to be due to a kind of atrophy and thinning of its walls, but it is now believed to be a genuine hypertrophy of the vessel itself in an effort to bring enough blood to the seat of the lesion to supply the distal parts satisfactorily even in the presence of the leak into the vein. The vein is also dilated distally up to the first valve and centrally for a much longer distance. Sometimes the valves in the large veins are forced by the pressure of the blood stream or by damming back of the blood and a large varicose tumor may result. The dilatation of the vein is much influenced by the surrounding tissue. The vein gradually thickens and becomes more and more like an artery.

Owing to the activity of the circulation in arteriovenous aneurisms and the great difference in pressure between the venous and the arterial trunks, clots rarely form and the prospect of spontaneous cure by clotting is very

slight indeed. The liability to rupture depends to a large extent upon the size and location of the sac. An aneurismal varix rarely ruptures. Sometimes the crowding of the arterial blood into the vein causes swelling from damming back of the venous blood, and at the same time nutritional disturbances may appear because too little blood enters the artery distal to the lesion. All of these things, however, depend entirely upon the location of the arteriovenous aneurism and upon the size of the opening. A very small leak will interfere but little, whereas a larger one may switch back so much of the blood that nutrition is greatly impaired. In large arteries an opening of considerable size may cause so much pressure in the venous system as to produce dilatation or hypertrophy of the heart. Probably some arteriovenous aneurisms gradually close without any surgical intervention. In experimental lateral arteriovenous anastomosis in dogs, this tendency to closure is marked. When this lesion occurs in the smaller arteries, watchful waiting will be the best treatment. If, however, the opening unites large vessels and if it is wide, permanent injury may be done to the heart, and it seems that such cases should be operated upon before the heart is damaged. If not operated upon, the patient should rest in bed and use measures that tend to reduce blood pressure.

The arteriovenous aneurism may appear immediately after the injury or after the lapse of some days or weeks. Cases are reported in which the symptoms occur months or years after the injury, but this is unusual and is probably due to yielding of the scar. Usually the clots and the pressure from the surrounding exudate will prevent a free communication for several days.

It has been the experience of many surgeons who have had considerable clinical material, that unless there is grave danger it is better not to operate upon these injuries too soon. The patient is given the benefit of rest and kept as quiet as possible to reduce blood pressure. Treatment is continued for two or three months after the injury unless there is a marked tendency for the lesion to become worse. At this time whatever sac may have formed will be firmly organized and the collateral circulation will be amply established.

If the injury can be recognized at once and the surroundings are satisfactory for immediate operation, it would seem best to operate as soon after the injury as possible. The vessels should be sutured according to the technic described in the chapter on Blood Vessel Suturing. Undoubtedly this is the ideal technic. Unfortunately, however, most of these cases occur in military surgery and the conditions of warfare do not often permit such immediate treatment. If operation cannot be done within a few hours or at least a few days after the injury it is better to postpone the operation for several weeks because the pressure of the hematoma, the swelling and the changes in the tissues such as exudate and leucocytic infiltration subsequent to the injury, soon impair the vessel wall so that it is difficult for sutures to hold. After this period has passed, which may occur in a few weeks, the tissues have again become firm and tough and suturing may be undertaken with safety. The disadvantage, however, is that the scar tissue makes the vessel walls tough,

and it is difficult or impossible to use fine arterial needles, so it may become necessary either to resect the affected portion of the vessel and transplant a vein or to resort to some method of ligation.

Immediately after the injury, if operation cannot be done, pressure over the lesion and on the main artery by a firm dressing and bandage and absolute rest are indicated. The various methods of ligation, except ligations close to the lesion, have not proved very satisfactory. Proximal ligation is often followed by recurrence and distal ligation alone is, of course, never indicated. Quadruple ligation, tying artery and vein both above and below, with or without extirpation of the sac has cured most cases, but it is often followed by gangrene if the ligatures are not placed close to the lesion.

The ideal treatment is restoration of the lumen of both the artery and the vein. The method of Matas, restorative endo-aneurismorrhaphy, may be practiced in many cases. In the technic for operation on aneurismal varix, as evolved by Matas and Bickham, after temporary hemostasis the vein is opened and the opening in the artery is sutured with curved needles as in the restorative aneurismorrhaphy. The vein is ligated above and below the lesion and the walls of the intermediate venous segment are sutured in layers as a reinforcement over the closed arterial opening. This can be safely done for the vein in this condition does not function as a vein because of the pressure of arterial blood, whereas in a simple arterial aneurism injury to the accompanying vein, which is normal in function, may result in a dangerous passive hyperemia.

If it is possible to secure complete hemostasis an operation that may be done is to dissect free both the artery and vein and to suture the wound in each vessel, following the technic of arterial suturing. This, of course, would necessitate the edges of the wound in the artery and vein being carefully cut away with sharp scissors, the adventitia removed, and the wound approximated according to the technic of suturing lateral or transverse wounds in blood vessels. Usually so much scar tissue has formed in the arterial walls around the opening that the fine arterial needles cannot be used and coarser needles and thread may result in too much leakage. As much tissue as possible should be preserved so that a double mattress stitch may be used, approximating accurately the intima and at the same time not sacrificing the lumen. The dilatation of the blood vessels toward the heart, together with the contraction below the lesion, places considerably more strain upon the sutures than would be after a wound of a normal vessel. This strain should be relieved by the application of a strip of fascia, a large absorbable ligature, the aluminum band or by infolding the artery according to Matas and Allen, in order partly to occlude the vessel proximal to the lesion; or a ligature may be thrown around the artery with instructions to tie it quickly if secondary hemorrhage occurs. If there is no infection the danger from secondary hemorrhage is over in a week or ten days.

When it is impossible or impracticable to secure complete hemostasis by a tourniquet the problem is much more difficult. If the nutrition of the limb

is seriously affected, or if the heart shows signs of failing under extra strain on the venous side, operation should be attempted. In a heart that is already incompetent, pressure upon the aorta or ligation of a large vessel might result disastrously and the safer method under such circumstances would be to

Fig. 73.—The author's forceps for lateral blood vessel suturing or for certain cases of arteriovenous aneurism.

Fig. 74.—Method of applying the forceps. The blades are soft and it is not always essential to cover the blades with rubber tubes.

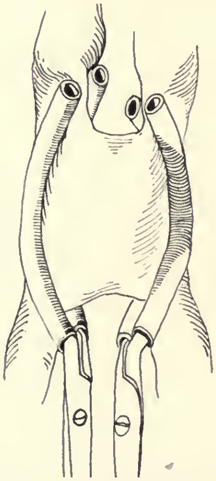

Fig. 75.—The vein and artery have been clamped with the forceps and their communication is about to be severed.

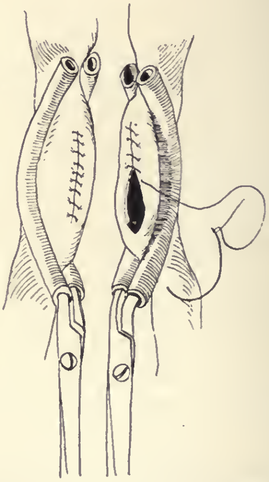

Fig. 76.—The communication between the artery and vein has been severed and is being sutured.

reestablish the circulation in both the artery and the vein. Here it may be possible to dissect both vessels carefully, exposing the lesion, and to grasp the artery and vein with curved forceps for lateral suture of blood vessels (Figs. 73 and 74). After grasping the artery and vein their communication is severed, the edges of the wound in the vessels are properly trimmed, and

with a cobbler's stitch in straight arterial needles or an overhand stitch in a curved needle, the opening in the artery and then in the vein is closed (Figs. 75 and 76). If it does not cause too much constriction of the lumen, a continuous reinforcing stitch may be placed over this. The lumen of the artery should be partially occluded on the cardiac side, as already mentioned. Often

Fig. 77.—Arteriovenous aneurism of the left femoral, near Poupart's ligament.

the tissues are too tough to use arterial needles and curved French intestinal needles may be employed.

In practical experience the late cases of arteriovenous aneurism are often best treated by ligation if the ligatures are applied close to the lesion. Suturing the defect in the vessel wall after a few weeks is a difficult or impossible task with a regular arterial needle and it is doubtful if resection of the vessels and transplantation of a segment of vein is justifiable except in very rare instances. The vein does not function as a vein, for the arterial pressure pre-

vents it, so there is not the same danger of tying it here as there would be in an arterial aneurism.

Among the larger vessels, the upper femoral region is the most frequent site of arteriovenous aneurism (Fig. 77). This region offers many difficulties in treatment because of its well-known vascularity and especially because of the collateral blood supply that comes from behind the artery through the deep femoral or through some of the internal branches of the femoral itself. The great enlargement of the veins from the pressure of the

Fig. 78.—The communication between these vessels was separated and sutured but the tissues were thick and the suturing was not satisfactory. Ligatures were applied, as shown in the illustration.

arterial blood in this neighborhood also adds to the difficulties. The veins in arteriovenous aneurisms in this region are sometimes exceedingly friable. In this location it is impossible to use a tourniquet satisfactorily, as it is too near Poupart's ligament. Hemorrhage has to be controlled either by careful dissection or by a laparotomy and pressure upon the external iliac artery or upon the aorta itself. There is a serious objection to the latter method, because pressure upon the aorta greatly increases blood pressure and throws extra strain upon an already damaged heart. Pressure upon the external

iliac would be less trying upon the heart, but it does not entirely cut off the blood supply to the affected region, which may not only go through the deep epigastric vessels, as when the aorta is occluded, but also through the free communications with many of the branches of the iliacs of the other side. Probably the best, though the most tedious, method is to dissect the vessels carefully and put a soft clamp on the artery and vein above and below the lesion, or if the opening is small and readily exposed the clamps for lateral blood vessel suturing may be used.

The ideal method in any operation is to restore tissues as nearly as possible to their normal condition, provided this can be done without too great risk to the patient's life. In other regions where the peculiar vascularity and the marked blood supply from behind are lacking, undoubtedly a more favorable opportunity will be found for suturing the vessels and restoring their

Fig. 79.—Method of applying ligatures in arteriovenous aneurism. A quintuple ligature.

normal caliber. Theoretically, this can be done in the upper femoral region, but, as a matter of fact, in two of my cases of arteriovenous aneurisms within two or three inches of Poupart's ligament, where the application of a tourniquet interferes with the operation, I have failed to reestablish the caliber by suturing (Fig. 78). The failure was due to several things: first of all, the vascularity of the posterior portion of the arteriovenous aneurism, which makes the necessary separation and mobilization of the vessels for suturing difficult and even dangerous; second, the friability of the new veins and tissues; third, the amount of scar tissue around the margins of a large opening; fourth, the free collateral circulation. On account of the normal vascularity of this region, collateral circulation is abundant after an arteriovenous aneurism.

Probably the most satisfactory operation for arteriovenous aneurism in the upper femoral region is a quadruple ligation as *close as possible to the*

lesion, together with one other ligature, making a quintuple ligation, in which a ligature of stout catgut passes under both artery and vein, both above and below the lesion and is tied en masse under these vessels so as to occlude the posterior circulation. (Fig. 79.) If this is not practicable on account of the large mass of tissue, a stout catgut ligature may be passed in the form of an X under the artery and vein just above the aneurism, then the long end from the arterial side is carried over the site of the lesion to the venous side and passed under the vein and artery just below the lesion. The two ends are tied firmly, which makes the ligature in the form of an X and will tend to occlude the posterior circulation to the aneurism (Fig. 79).

The success of these ligatures depends largely upon a careful dissection of the arteriovenous aneurism, taking great care to preserve the collateral circulation and to place the ligatures so close to the lesion that no collateral arterial branches will be closed. This not only adds to the prospects of cure, but lessens the strain on the heart.

CHAPTER XI

OPERATIONS FOR REPAIR OF NERVES

Operations on the nerves for the restoration of their function may be divided into neurolysis and nerve suturing. Neurolysis consists of freeing a nerve from scar tissue. Suturing nerves may be the direct suturing of divided nerves end-to-end, or the interval may be bridged by a graft of nerve tissue. This is either turned as a flap from the proximal or distal portion of the nerve or a free transplant of nerve tissue may be taken from some uninjured nerve, or a tube of tissue may be made to connect the ends of the nerve. Another method consists in the implantation of the distal portion of the injured nerve into a sound nerve that has the same type of function.

There is some difference of opinion among neurologic surgeons as to the technic and to some extent as to many of the principles of nerve suturing. This may be expected because of the high degree of complexity of nerve tissue and the difficulty with which the regeneration of nerves can be satisfactorily demonstrated. Some histologists, for instance, claim that practically all nerve tissue is regenerated from the central stump, and others hold that the distal stump takes an important part in the repair.

Recent work in the regeneration of severed nerves seems to show that while the central stump is the chief factor in nerve regeneration the distal stump also has an important part. The excellent work of Kirk and Lewis has thrown considerable light upon the subject. They have shown that protoplasmic bands are formed by the proliferation of the neurilemma cells, and that while these bands come from both the central and distal stumps, the greater portion is from the central end of the nerve. All of these protoplasmic bands seem to form conduits down which the new axis cylinders grow. All axis cylinder formation, however, comes from the central end of the nerve. Sometimes several axis cylinders or axons follow a single protoplasmic band. Frequently many of them do not enter the distal nerve stump, but will curl up on the proximal side and form an enlargement, a so-called neuroma. A neuroma consists largely of the connective tissue multiplication from the sheath of the nerve fibers into which the axis cylinders have grown or have become entangled. Sometimes the connective tissue may be so dense as practically to destroy the axons. In a completely divided nerve the neuroma on the central end is much more prominent than that on the distal end, because on the central end the axons in their efforts to reach the distal stump become entangled in the connective tissue proliferation and produce an enlargement with considerable regularity. In the distal portion, however, a neuroma consists only of the connective tissue proliferation, in which the degenerated axis cylinders that existed

after the injury become entangled, as there is no true regeneration of the axis cylinder in the distal stump unless it has been connected directly with the central stump. No regeneration can occur except in nerves that have a neurilemma, or sheath of Schwann. The medullary sheath is not essential to regeneration. The neurilemma cells take a most active part in regeneration and though they seem only to form conduits through which axons grow from the central end of the nerve, these conduits appear to be essential to the growth of the axons.

There are more axons than central nerve cells because some axons branch. When this branching occurs it is always at a node of Ranvier. Thus a nerve cell that has two axons may function even if one of them is destroyed.

Nerves histologically similar often regenerate with different degrees of readiness. The sensory fibers of the fifth nerve regenerate rapidly and perfectly, while a mixed or motor nerve regenerates with much more difficulty. There are also differences in the readiness of repair of many mixed spinal nerves.

It is important to bear in mind these facts in order to conceive the objects of nerve suturing. In such delicate tissue as nerves it is natural to expect that the greatest gentleness must be used in any surgical manipulation. In the limbs it is best to do the operation without a tourniquet for three reasons: (1) the pressure of the tourniquet may bruise the nerve, (2) the tissues in the region of the operation and distal to the tourniquet are deprived of their nutrition during the application of the tourniquet, and (3) there is great likelihood of excessive oozing in the operative field after the tourniquet has been removed.

No attempt should be made to expose the nerve at the site of injury until after it has been thoroughly uncovered in its healthy portion, both central and distal to the injury. The nerve should not be handled if it is possible to avoid it. The tissues are dissected away from the nerve instead of dissecting the nerve away from the tissues. It is important to isolate the nerve to no greater extent than necessary. It must be remembered that the regeneration of the nerve will depend to some degree upon its blood supply for if it is dissected too freely from its surrounding tissues, even though the nerve suturing may be properly done, the nutrition of the nerve may be so poor that failure will result. It is for the same general reason that a blood vessel should not be dissected from its bed for fear of interfering with the nutrition of its walls. Flaps in plastic work heal best, other things being equal, when there is a good blood supply.

After the nerve has been satisfactorily exposed, both distally and proximally to the injury, dissection is carried to the point of injury and this region of the nerve is mobilized by sharp dissection. If it has been determined that the function of the nerve is abolished and if a sufficient period of time, four to six months, has been permitted to elapse since the injury to the nerve without reasonable improvement, resection of the injured portion should be seriously considered. If the nerve ends have been completely divided and terminate

in neuromas, of course the union of the nerve by suturing must be done. In some instances, while the continuity of the nerve has not been destroyed the scar tissue has so infiltrated an injured segment of nerve as to make it functionally useless, and resection and suture are demanded. Sometimes a neuroma occurs on a portion of the nerve while the rest of the nerve is healthy, and in such cases the neuroma can be dissected away, leaving the healthy part.

In cutting away neuromas or scar tissue from the end of a nerve, it is highly important, as Dean Lewis and others have insisted, to remove all the scar tissue and go into healthy nerve fibers. In order not to waste useful tissue it is best to cut the scar tissue away in small sections until normal nerves have been exposed. It is utterly useless to suture a nerve that is infiltrated with dense scar tissue, and it is better to leave a considerable interval between two healthy nerve ends than to approximate neatly the ends of nerves containing dense scar tissue.

The nerve ends should never be caught with forceps and should be severed with a sharp knife. The bleeding in the nerve ends should be thoroughly controlled. In some large nerves, as the sciatic, the bleeding vessel can be demonstrated and caught with mosquito forceps and tied without injury to the surrounding nerve fibers. Gentle pressure of gauze for a few minutes will control slight bleeding. If the nerve ends are sutured together while bleeding, or if a hematoma forms between the nerve ends, an excessive amount of connective tissue, which is the bane of nerve surgery, may form.

The nerve ends should be brought together end-to-end and without axial rotation so that the ends of the nerve fibers in the central stump will as far as possible be approximated to the ends of corresponding fibers in the distal stump. All manipulations such as freeing the nerve and hemostasis are completed before the nerve is divided or the scar tissue dissected away. The injured portion of the nerve can be siezed and traction made from this portion, so avoiding undue manipulation of the healthy nerve fibers. It is best to leave a small tag of scar tissue on each stump which can be clamped and will serve as a handle to manipulate the nerve ends while they are being sutured. This tag is cut away after most of the sutures have been applied and the nerve fibers that have been covered by the tag are sutured to the corresponding nerve fibers on the other side. In this way, too, axial rotation is prevented. A suture of fine arterial silk near each end of the nerve, penetrating only the sheath, may also be used to prevent axial rotation.

As to suture material, either catgut or very fine silk is used. If there is no great degree of tension, plain catgut should hold the nerve in position sufficiently long. If it is desired for the suture to have a more lasting effect mildly chromicized or tanned catgut can be used. Fine black silk either 00 or arterial 00000 silk, in arterial needles, which is better still, is a good suture material. If the nerve is large, one or two sutures of fine silk or catgut are placed through each nerve stump. These act as tension sutures. The other sutures of arterial silk are inserted into the nerve sheath and

go a short distance below the sheath so as to catch a firm hold. Fine silk, preferably arterial silk, is excellent for these sutures which are best placed as interrupted mattress sutures. In larger nerves a continuous suture of this silk can be used as an epineural suture around the entire nerve sheath after inserting a few interrupted sutures as tractor sutures. It is important not to injure the nerve fibers by catching them in a suture, but it is still more important to have a sufficiently firm bite on the tissues so that the sutures will not cut or pull out. After inserting the chief sutures the ends of the nerve are approximated and held in position by the fingers of an assistant and then the sutures are tied just snugly enough to keep the ends of the nerves well in apposition (Fig. 80). The assistant should not relax the nerve ends until every suture has been tied. In this way undue tension on any sin-

Fig. 80.—Appearance of nerves after suturing.

gle suture is avoided and there is less likelihood of the suture breaking or pulling out. If the central or tension suture appears unnecessary after the sutures in the nerve sheath have been tied, it may be removed. Except in the smallest nerves, at least three sutures should be inserted in the sheath of the nerve. There should be no tension on the sutured nerve. To avoid this the position of joints near the sutured nerve may be utilized. Thus, the elbow can be flexed to relieve tension on the median and musculospiral, or extended when the ulnar nerve is sutured. The ulnar may be displaced to the front of the elbow, taking care not to injure its muscular branch to the flexor carpi ulnaris, and the elbow is then flexed.

There has been much discussion as to the prevention of adhesions and contraction at the site of the nerve suturing. A variety of applications has been suggested, including sections of blood vessels that have been hardened in formalin and various kinds of foreign bodies, as rubber and bone tubes.

It is well to follow the general principle not to clutter the site of operation with foreign or extra tissue unless there is a distinct benefit to be derived from it. If the nerves can be well approximated and if the site of union can be placed in or covered by healthy muscle, fascia or fat, along the normal course of the nerve and if there is no large amount of scar tissue in the neighborhood, nothing else is desired. If the ends of the nerves cannot be made to meet, however, some form of tube construction preferably a tube either lined with or constructed of fat can be used. Dean Lewis has secured satisfactory results with a tube of fascia lined with fat, fastening the ends of the nerve that could not be approximated into each end of the tube.

If around the site of nerve suturing there has been considerable scar tissue, the sutured nerve should be protected. This is best done by first dis-

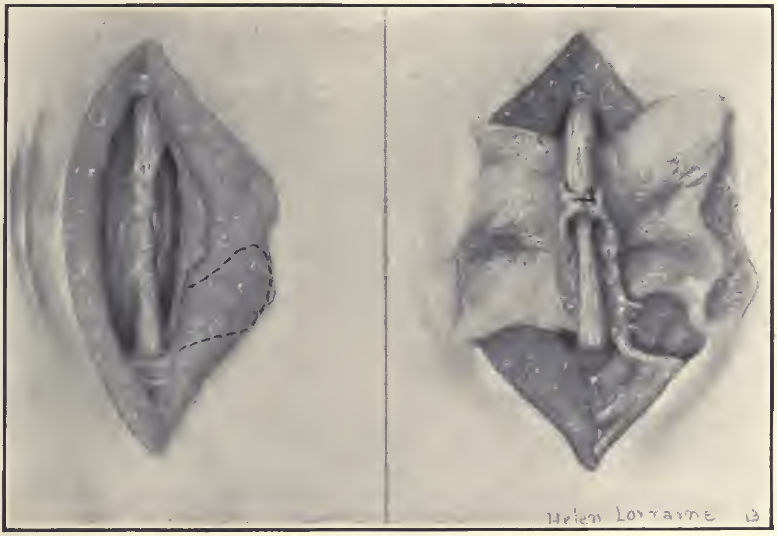

Fig. 81. Fig. 82.

Fig. 81.—Dissection of binding scar tissue from a nerve, with outline of a pedicle flap.
Fig. 82.—Pedicle flap applied around the old site of scar contraction.

secting away the scar tissue around the nerve as freely as possible, controlling bleeding, and then shifting the nerve so it will lie in a normal plane of intermuscular fascia. If this is impossible the sutured nerve may be protected by a pedicled flap of fascia and muscle or fascia and fat, placing the fat next the nerve (Figs. 81 and 82). If the pedicle is well nourished the flap will aid in blood supply to the injured nerve and so tend to avoid excessive scar tissue formation. No bleeding surface such as cut muscle, should ever be placed in contact with the sutured nerve. The interposition of tissue as a free graft around the sutured nerve tends to isolate the nerve from the nutrition that can be derived from the blood supply of its adjoining tissues.

Every effort should be made to secure an end-to-end union of healthy nerve tissue. If a reasonable dissection cannot give satisfactory approximation, sometimes a change of position of the limb will make it possible to

bring the nerve ends together. Thus the hand may be flexed in suturing the median nerve or the knee in suturing the sciatic. The limb must be put up in splints or plaster of Paris and kept in the flexed position for at least two months after the operation.

Occasionally, however, in spite of manipulation of the nerve and of the limb there will be a gap between the ends of the nerve, and the problem arises of what is to be done to bridge the defect. Four courses have been recommended: (1) suturing the ends of the nerve into a tube of fat and fascia, (2) free transplantation of a nerve graft from an uninjured nerve, (3) transplantation of the distal end of the nerve into another healthy nerve of somewhat similar function, and (4) flaps taken from the injured nerve.

(1) This method of using a fatty fascia tube and suturing the ends of the nerve into the tube so that the fibers will more readily reunite has been de-

Fig. 83.

Fig. 84.

Fig. 83.—Excision of neuromas from a divided nerve.

Fig. 84.—Application of a tube of fat and fascia between ends of a nerve that cannot be approximated. (Method of Dean Lewis.)

veloped by Dean Lewis and has given good results in some cases in his hands, though its place in surgery according to Lewis has not been definitely established (Figs. 83 and 84). Edinger states that the fibers of human nerves grow best in a medium of agar and after filling a segment of an artery or a vein with agar he sutures the ends of the nerves into this segment. This has not proved satisfactory. Foreign material such as rubber tubes should not be used.

(2) A free graft of a nerve may be taken from a nerve of different function. A gap in a motor or mixed nerve, such as the facial or musculospiral, may be bridged by a segment from a purely sensory nerve as the radial or the internal cutaneous. A segment of the nerve is removed, taking

care that it should be of ample length and sutured to the ends of the nerve with the same technic that would be used in uniting the nerve end-to-end. The graft is usually much smaller than the nerve and the supply of material from which the graft can be taken is practically limited to the radial, internal cutaneous or the intercostal nerves. When the disparity between the size of the graft and the size of the injured nerve is too great a "cable" graft, made up of several segments of the nerve to be grafted, can be used. The segments which should be handled as little and as gently as possible, are cut of the proper length, held together at their ends by sutures and then transplanted.[1] Elsberg places these sutures before the segments are cut as shown in the illustration (Figs. 85, 86 and 87).

(3) The distal end of the nerve may be transplanted into a neighboring nerve of somewhat similar function; for instance, a motor or a mixed nerve

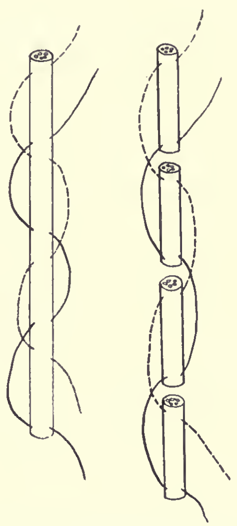

Fig. 85.—Elsberg's method of cutting sections of a small nerve for cable transplantation.

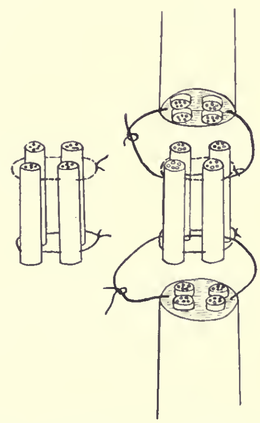

Fig. 86.—Cable shown in Fig. 85 is being sutured into the defect between the ends of the nerve.

must always be transplanted into a motor or a mixed nerve. For regeneration it is best to transplant the nerve end-to-end, severing the healthy nerve and uniting its central end to the distal end of the injured nerve. This, of course, sacrifices the function of a healthy nerve and to overcome this sometimes the distal end of the injured nerve is transplanted into the side of the healthy nerve, making an end-to-side transplantation, or both free ends are transplanted end-to-side into this nerve trunk. Of course, in end-to-side implantation a wound must be made in the side of the healthy nerve trunk that will expose some of its axis cylinders (Fig. 88).

(4) Bridging a defect in a nerve by flaps taken from the ends of the nerve is a procedure that is probably without value, though much interest

[1]Jour. Am. Med. Assn., Nov. 8, 1919, pp. 1422-1427.

has recently been created in this method by Mackenzie, who reported several cases.[2] (Fig. 89.) In one patient a defect of ten and three-quarter inches in the sciatic nerve was bridged with flaps from the central and the distal ends of the nerve. Byron Stookey[3] reviews this case carefully and shows that the improvement was probably due to the fact that flexor muscles of the leg, the hamstring muscles, have a double nerve supply and that the upper supply was never injured by the resection of the sciatic. The technic of making nerve flaps is such that in making the flaps about one-half of the nerve is sacrificed. It is not conceivable that the central end of the axons that are divided when the flap is cut from the central stump can ever unite to any other axons. If the flap is from the distal nerve stump it thus destroys a large part of the peripheral distribution of the nerve. A reference to the diagram of

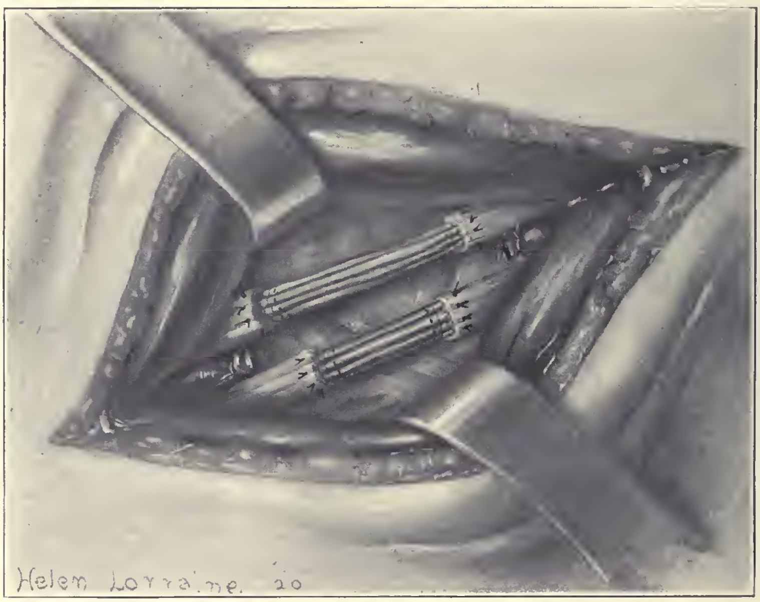

Fig. 87.—Appearance of nerve after cable graft has been completed, according to Elsberg.

a nerve flap operation (Fig. 89) shows that the ends of the axons are not in contact and not in the same direction and it seems difficult or impossible for the ends of the central axons to reach the ends of the axons in the flap, and unless the ends of these axons unite there is no regeneration. It must be borne in mind that the histologic repair of the nerves is very different from that of other tissue such as tendons and blood vessels. No new axons are ever formed and all that surgery can do is to connect peripheral axons with central axons or to provide a direct and easy path for growth from the central end. Experiments by Huber[4] show there is no regeneration after flap operations on dogs.

[2]Ann. Surg., 1909, l, 295; Surg., Gynec. & Obst., Oct., 1918.
[3]Surg., Gynec. & Obst., Sept., 1919, pp. 287-312.
[4]Surg., Gynec. & Obst., Dec., 1917, pp. 595-604.

Moynihan is quite positive that grafts and transplantation of the nerves should not be done. He thinks that only end-to-end union is satisfactory and goes so far as to resect the bone of a limb in order to secure it. Other neurologic surgeons do not agree with him. It is undoubtedly true that, while end-to-end union gives the best results and transplantation and various methods of bridging gaps have not been anything like as satisfactory as the end-to-end union, there are still a sufficient number of cases recorded to make it certain that some of these methods that are condemned by Moynihan are not without value. For instance, there are many cases in which the distal

Fig. 88.—End-to-side suturing of a nerve.

end of the facial nerve has been implanted either into the hypoglossal or the spinal accessory and in which the results have been very satisfactory. Thus Adson[5] reports the final results of anastomosis of the facial nerve to the hypoglossal in one case and to the spinal accessory in eight cases. Eight of the operations were end-to-end. The average amount of motor return estimated by quantitative examination of power and control of the facial muscles was seventy-one per cent of the normal function in this group of cases.

Much of the disagreement in the value of results of nerve suture, and particularly of nerve transplantation, is due to the fact that some nerves regenerate more promptly and more satisfactorily than others, and that in

[5]Ann. Surg., August, 1919.

some individuals the nerve tissue will regenerate very much better than in other individuals. In a young healthy child complete regeneration is much more probable than in an adult. Experimental work in lower animals may show better results in nerve surgery than are obtained clinically, whereas in tissue of less delicacy there is not the same difference in regeneration between lower animals and man.

The technic of nerve suturing that has been described is applicable in

Fig. 89.—The method of bridging a defect in a nerve by flaps. The drawing shows the apparent impossibility of the nerve fibers regenerating after such a method.

any form of nerve operation, but there are two operations for injured nerves that have been so standardized as to make it advisable to describe these procedures. The first is the operation for peripheral facial paralysis, and the other is the operation for paralysis following injuries to the brachial plexus. This latter type of paralysis is often found in infants where it is due to injury of the brachial plexus resulting from prolonged and difficult delivery.

In the operation for peripheral facial paralysis it is usually necessary to anastomose the distal end of the facial nerve to some other nerve of simi-

lar function. It may occasionally be possible to make an end-to-end suture of the facial nerve if the injury occurred between the emergence of the nerve from the stylomastoid foramen and the point at which its main branches are given off in the parotid gland. Such an injury, however, is rare and the technical difficulties of suturing would be great. Practically all paralyses of the facial nerve are due to injury of the nerve between its origin and its emergence from the stylomastoid foramen. A large portion of the injuries to this nerve are sustained by that portion that lies in its canal. At this point, too, inflammation extending from the ear or from the mastoid cells may cause such disease of the nerve as to produce paralysis. Before operation is undertaken it should be definitely ascertained that the distal portion of the nerve is capable of conducting impulses. This can be done by electrical tests.

In the operation for anastomosis of the facial nerve two nerves have been employed, the spinal accessory and the hypoglossal. Both of these nerves are motor in function like the facial and are in convenient proximity to the facial nerve. The spinal accessory, or 11th nerve, supplies the sternomastoid and trapezius muscles while the hypoglossal goes to the muscles of the tongue.

Some surgeons have found that after anastomosis of the facial and spinal accessory the associated action of the muscles of the face and the shoulder region are so marked as to interfere materially with the success of the operation. For this reason many surgeons prefer to use the hypoglossal nerve instead of the spinal accessory. Technically, there is not much difference in either operation and the incision can be the same. The incision is made along the anterior border of the sternomastoid muscle, beginning in the groove between the external ear and the mastoid and extending downward about five inches. The ear is retracted forward, the fascia covering the mastoid is incised, and the anterior border of the sternomastoid muscle is exposed. With blunt dissection the incision is carried down between the parotid and the anterior border of the mastoid. The facial nerve is found at a depth of about one-half inch from the surface of the mastoid process and at the junction of its lower and middle thirds. The facial nerve should be dissected out gently, taking care to avoid catching it with forceps, and the dissection is carried back as far as possible. In some instances, a portion of the mastoid process and temporal bone can be cut away so that the nerve can be divided higher up in its bony canal. This, however, is not necessary as a rule. The facial nerve may be surrounded by a loose loop of catgut so that it can be readily identified, but it should not be divided until the nerve into which it is to be implanted has been dissected free. It is important to dissect the facial nerve before proceeding further with the operation, because cases have been found in which the facial was either missing or converted into a fibrous cord. In such instances, of course, the operation would be abandoned. During the whole of the dissection care should be taken to avoid soiling the wound with blood. The vessels should be clamped or the oozing controlled by gauze compresses.

The spinal accessory nerve is found by first demonstrating the trans-

verse process of the atlas, which is about one-half inch below the mastoid, and then the posterior belly of the digastric muscle in front of the atlas. The spinal accessory nerve lies between the transverse process of the atlas behind and the digastric muscle in front. The hypoglossal nerve is probably more closely related to the nerve centers of the facial muscles of expression than are the centers of the spinal accessory nerve (Fig. 90).

The hypoglossal nerve is best located where it crosses the external carotid artery just below the occipital branch of the external carotid. Here

Fig. 90.—Suturing the hypoglossal nerve to the facial nerve. The spinal accessory nerve is also exposed in the same drawing.

the hypoglossal nerve curves forward and to the outer side of the external carotid and then it lies between the posterior belly of the digastric muscle externally and the hypoglossus muscle internally. About one and one-half inches of the hypoglossal nerve are dissected free and at least one-half inch of the facial nerve. After exposing fully the hypoglossal nerve the facial nerve is cut as close to its point of emergence from the skull as possible. The stump is then drawn down and the hypoglossal nerve is cut at such a point that its central end can easily be sutured to the peripheral end of the facial nerve without tension. The suturing is done with three or more sutures of fine arterial silk, using the technic that has been described in nerve

suturing. Because these nerves are small, simple interrupted sutures of arterial silk are best. If the operation has been dry and if no blood has been permitted to smear the wounded nerves, union will probably be satisfactory. It is best to flush out the wound with salt solution in order to remove any small amount of blood that may have oozed. Some operators cover the site of anastomosis with fat in order to prevent adhesions. The late John B. Murphy advised that the site of the union be buried in muscle tissue, preferably in the belly of the stylohyoid muscle. If the dissection has been carried out carefully without the loss of blood and if the tissues have been handled gently it is not likely that cicatricial contraction will occur. If any substance is used to protect the line of anastomosis it would probably be best to use a pedicle flap of fat and fascia. The wound is closed by suturing it lightly, closing the deep wound with a few catgut stitches, and the skin preferably with silk or silkworm-gut.

Various operators of experience have modified the technic as described. In some instances the end of the facial nerve has been implanted laterally into the hypoglossal, after nicking the hypoglossal slightly. In this manner it has been claimed that the function of the hypoglossal is not materially interfered with and the muscles of the tongue are not greatly affected. It seems, however, that regeneration of the facial nerve and facial muscles is not so complete after an end-to-side anastomosis as after an end-to-end union.

A. W. Adson,[6] of the Mayo Clinic, reports that of nine anastomoses of the facial nerve which have been done at the Mayo Clinic, eight have been followed up and examined at intervals after the operation or have reported by letter. One of the nine patients has not been heard from. The average time before improvement was noticed in these cases was 7.9 months and the average amount of return of motor function was about 71 per cent of the normal.

Operations for paralysis of the muscles supplied by the brachial plexus are often done in infants, as this type of injury frequently follows difficult labor. This injury, too, is not infrequent from blows on the shoulder or from a sudden trauma that carries back the shoulder and bruises the brachial plexus by the pressure of the clavicle. If the clavicle is fractured, as usually occurs, no harm is done the plexus, but if the clavicle holds, serious damage may be done to the brachial plexus which may result in immediate paralysis of those muscles supplied by the injured portion of the plexus.

In injury to the newborn, or so-called obstetrical palsy, there is not infrequently a dislocation of the shoulder joint. This may occur with or without injury to the brachial plexus, and, as Turner Thomas[7] has vigorously pointed out, it is quite possible that the shoulder lesion may have been frequently overlooked. If there is a dislocation of the shoulder and it is reduced and the shoulder and arm are elevated and fixed, the patient is put in the most favorable position for the healing of any injury to the brachial

[6]Ann. Surg., August, 1919, p. 161.
[7]Ann. Surg., February, 1914.

plexus that may have occurred at the same time. Though many cases that have been called injury to the brachial plexus have been chiefly or solely injuries to the shoulder joint, there is no reason for denying the existence of serious injury to the brachial plexus that may cause paralysis without an accompanying shoulder lesion. Such lesions of the brachial plexus are not infrequently seen in adults as the result of trauma.

In operations for this condition Sharpe[8] advises a transverse incision, preferably in one of the horizontal folds or creases of the skin just above and parallel to the upper part of the clavicle. In an adult this incision would hardly be satisfactory, though it seems sufficient in an infant. In adults, the incision should begin at the upper portion of the lower third of the outer margin of the sternomastoid muscle and go outward and downward to the junction of the outer and middle thirds of the clavicle. The transverse incision of Sharpe for infants is only about two inches in length and is made about

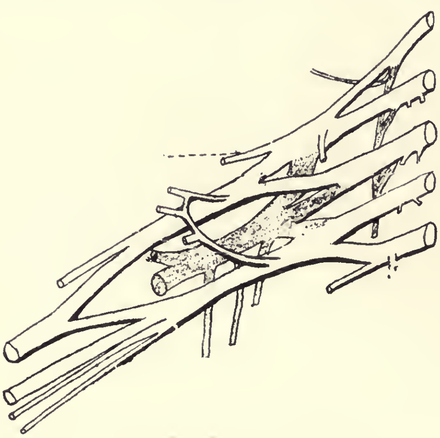

Fig. 91.—Diagram of the brachial plexus. (After Gray.)

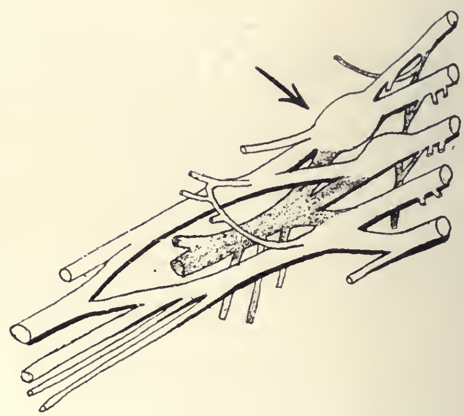

Fig. 92.—Injury of the upper trunk of the brachial plexus.

one-third of an inch above the clavicle. The external jugular vein is doubly ligated and divided, the sternomastoid and the omohyoid muscles are retracted, and the cervical fascia which overlies the plexus is incised. The transverse process of the sixth cervical vertebra, the carotid tubercle, is at the level of the junction of the fifth and sixth nerve roots and serves as an excellent guide. The nerve trunks of the brachial plexus emerge from beneath the scalenus anticus muscle. While exposing the brachial plexus the location and course of the suprascapular nerve should be ascertained, as it is important not to injure this nerve. After the brachial plexus has been freed the lesion is most frequently found in the upper trunks, that is in the fifth, sixth and seventh cervical, though in breech presentations and in injuries in adults, especially those caused by the clavicle, the lower portion of the brachial plexus is usually affected. If the nerve roots are completely

[8]Jour. Am. Med. Assn., March 18, 1916, p. 880.

torn their stumps are found and sutured together, taking care to remove all the scar tissue. The technic of suturing has been described.

By elevating the shoulder and inclining the head and neck to the affected side, a gap of one inch in the upper trunks of the brachial plexus can be readily overcome (Figs. 91, 92 and 93).

If the lesion is in the lower portion of the plexus it may be necessary to divide the clavicle and a portion of it may be resected permanently if it adds to the relief of the tension. If in spite of posture, it is impossible to approximate the ends of the cords or trunks or if the lesion seems to extend into the spinal column,

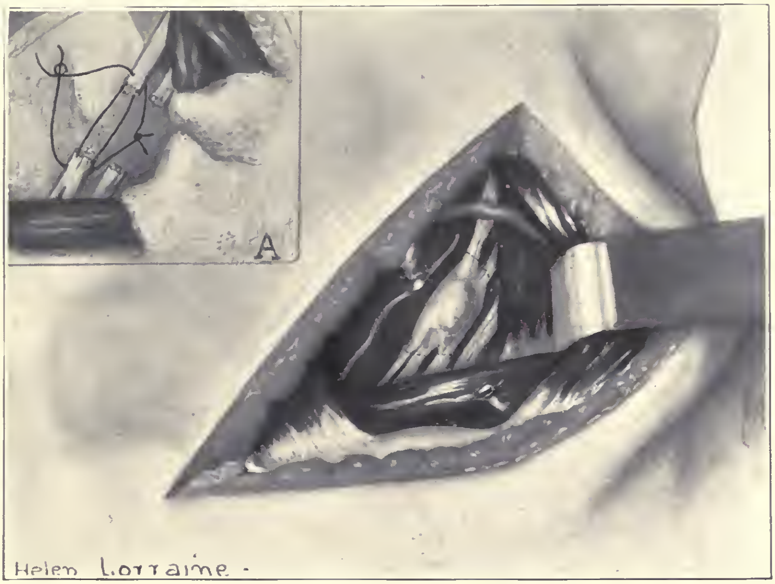

Fig. 93.—Excision of the injured portion of the brachial plexus. Insert (a) shows the sutures applied. The ends can be approximated as the sutures are tied by elevating the shoulder and turning the head and neck to the affected side.

the healthy distal portion of the brachial plexus is cut across and the stump sutured end-to-side into the nearest cord after incising the sheath and a few nerve fibers in order to make contact with the axons. Here, as in all nerve surgery, the wound must be kept as free of blood as possible. An excellent posture for the postoperative treatment is to bring the hand on the affected side over the head until it touches the opposite ear and to fasten the arm in this position by adhesive and bandages.

Some surgeons, as Tubby and Hildebrand, have endeavored to correct the deformity caused by brachial palsy by transplanting muscles, Tubby transplanting a portion of the triceps muscle and Hildebrand the pectoralis major. It has been shown experimentally that if the nerve supply of a muscle is maintained uninjured the muscle can be transplanted freely with but little regard for its blood supply, except that portion that affects the nerve. The muscle will probably partially degenerate, but with its uninjured nerve supply it

will regenerate. Hildebrand's operation takes advantage of this and maintains the nerve supply of the major pectoral muscle which comes through the anterior thoracic nerves. He dissects free the major pectoral at its origin and turns up the muscle, suturing it to the outer third of the clavicle and to the acromion process, leaving its insertion and nerve supply intact.

After all operations for restoration of motor function it is essential to carry out after-treatment in which massage and electricity are intelligently applied for a number of months. Such treatment not only hastens regeneration of the nerve but keeps the muscles in a healthy condition, prevents their atrophy and renders them better able to function when the nerve regenerates.

Neurolysis means freeing a nerve from pressure and adhesions. The process is the same as when preparing a nerve for suture by dissecting away surrounding scar tissue. Sometimes the nerve fiber bundles are freed by longitudinal incisions made in the nerve with a fine sharp knife. Precautions are taken to prevent reformation of adhesions as after nerve suturing.

CHAPTER XII

OPERATIONS ON BONES

The results of operations on bones illustrate very strikingly the great value of the application of the knowledge of the biologic reaction of bone to infection and to foreign substances. To plan intelligently operations upon bones it is necessary to have in mind the biologic processes of bone repair. While the discussion still goes on as to some of the details of repair of bone, the fate of bone grafts, and the part played by the periosteum, there are certain fundamental principles that are well established. Whether the periosteum takes active part in the reproduction of bone, or, as MacEwen claims, is merely a limiting membrane, depends largely upon the definition of periosteum. If the cambium layer on the cortex of the bone is included with the periosteum, it is undoubtedly true that this layer contains osteoblasts and will reproduce bone. If this layer is not considered as a part of the periosteum proper, the periosteum then is only a limiting membrane.

In infection of the bone, however, which is not too rapid many osteoblasts migrate from the bone and may penetrate all of the layers of the periosteum. In such instances even the more superficial part of the periosteum may actively participate in the reproduction of bone. When the infection is very virulent and overwhelming or when the nutrient artery of the bone is early occluded by inflammation, there may not be time for the osteoblasts to migrate and here the periosteum will react in the same manner as would the periosteum over a normal healthy bone and will only reproduce bone from the cambium layer. A knowledge of these facts is particularly important in operating upon osteomyelitis, because if the infection is not too virulent many osteoblasts may have time to escape to the periosteum where they will live because of the good blood supply, though practically all of the shaft of the bone may eventually be destroyed by the inflammation. This also explains the development of an involucrum which encloses what seems to be a completely necrotic shaft of the bone. The reproduction of the shaft of a long bone from the periosteum, is not infrequently seen and, as has been pointed out by Nichols, if the necrosed shaft is removed at the proper time when the activity of the periosteum is at its height, reproduction from the periosteum is very satisfactory. If, however, this is attempted in a normal bone, reproduction of the shaft will not take place unless a thin layer of the cortex or the full cambium layer is permitted to adhere to the periosteum.

In bone grafting, as in transplanting other tissue, the grafts should be taken from the patient. It seems quite certain that grafts taken from lower

animals act only as a foreign body and it is doubtful whether grafts even from individuals of the same race will be satisfactory.

It is best to have the bone grafts in contact with other living bone, but this is not essential, as Carter[1] shows. Carter reported twenty cases in which bone grafts were used to elevate the nose and in many of these cases the grafts were not in contact with the bone of the face, but imbedded in soft tissue. Two to three years after the operation these transplants were still in place and some of them larger than when they were implanted.

Wolff's law is important to bear in mind when grafting bone. According to this law change in the form, position or function of bones is followed by definite changes in their internal structure and also by alteration of their external conformation in accordance with mechanical laws. The workings of this law are observed when a small graft is inserted in the defect of a large bone and gradually develops to the size of the large bone. When a graft is taken from one tibia to fill a total defect in the other tibia, it has been frequently observed that in the course of time both tibias appear of normal proportions. If the fibula is grafted to make up the defect of a tibia it will hypertrophy to the size and general contour of the tibia. This only happens, however, if the strain and stress to which a normal tibia is subjected are gradually applied to the graft, which seems to react from the stimulus of the gradually increased function of the leg.

In spite of the similar construction of bone as observed histologically, there is a considerable variation in its function. Some bones, as those of the fingers, receive quick and numerous though light strains. Others, as those of the leg, are capable of great weight bearing and of active motion. Still others are comparatively fixed and merely serve to hold the contour of the soft tissue they support. It seems that in grafting bone it is well to consider its function. If an active bone accustomed to motion and strain is to be repaired it would be wise to take a graft from a bone of similar function. The bones of the arm, for instance, could be repaired from the bones of the leg. For bones of the face or skull, however, whose function is passive, grafts may be taken from bones of similar function which would correspond to the ribs more nearly than to the bones of the leg.

Whenever possible the periosteum should be attached to the graft. This is not only because the layer of the periosteum next to the bone, the cambium, is capable of reproducing bone, but because the nutrition of the graft is much better if the periosteum is preserved. McWilliams particularly has called attention to the fact that the nutrition of a bone graft can be carried on more readily when the periosteum is preserved because anastomosis of the vessels in the surrounding soft tissue with the vessels of the bone occurs much more quickly and freely through the medium of the periosteum than with the bone graft without periosteum. In this latter instance bone salts must be absorbed before definite connection with the vessels of the interior of the bone can be established, whereas there is no obstacle to the connection between

[1]Med. Rec., New York, February 7, 1914.

the vessels of soft tissue and those of the periosteum. The vessels in the periosteum have their normal anatomic communication with the vessels of the bone.

The action of bone grafts depends upon a number of biologic factors. In some individuals there is an idiosyncracy for the deposit of calcium and but little callus is ever formed, even though the patient may be otherwise healthy. The presence of syphilis and other diseases is supposed to interfere with the deposit of lime salts in the callus. The free use of irritating antiseptics, the presence of infection, or certain infectious or contagious diseases may interfere with the repair of bone after a fracture or grafting.

The nutrition of grafts and of the bone to be repaired is of great importance. Here as elsewhere in surgical operations, the nutrition to the parts affected should be preserved. Other things being equal, tissues with the best nutrition repair most readily. The blood vessels to the parts should be respected and preserved. It is best to do the operation without a tourniquet so that the nutrition of the limb is not interfered with during the operation and because hemostasis after the operation is more satisfactory if the wound is closed dry, without a tourniquet being used.

The problem of nutrition concerns not only the supply of blood to a part but the amount of tissue that has to be nourished. A lack of consideration of this feature may lead to erroneous conclusions. The surface of a solid body varies as the square, and the cubical contents as the cube of its dimensions, so the smaller the graft the greater is its surface in proportion to its cubical contents and the less the burden of the nutrition to the graft. It is, of course, necessary to have a graft of sufficient size to bear the strain that is required but this does not mean that the strain of the full physiologic function of the bone must be provided for by the graft. Due consideration must be given to the hypertrophy of the graft under moderately increased functional strain and the smallest graft that will meet these demands should be selected. A small graft that offers a small mass to be maintained from the nutrition of the local tissues will undergo more active growth than a large graft placed under similar conditions, which will add a much greater burden of nutrition to the surrounding tissues. We know that physiologic function is in many instances altered to a large extent by the supply of nutrition that tissues receive. It is natural, then, to expect that when a definite amount of nutrition is divided among cells of a large graft, osteogenesis will not be so rapid or so satisfactory as when the same amount of nutrition is distributed to the smaller number of cells in a small graft.

While it is essential to maintain a bone graft immobilized much longer than a simple fracture, gradually increasing exercise or massage should be begun as soon as possible after the period of immobilization has ceased. Grafts in the limbs should always be kept immobilized for a minimum of eight weeks and in the large bones, as the femur, this period of time should be greatly extended before weight bearing is begun. Splints or braces should always be used to take up a part of the strain on the newly united graft.

A knowledge of the reaction of bone to foreign material is essential to a satisfactory performance of operations on bones. As has been mentioned in the chapter on Surgical Drainage, bone tends to extrude irritating foreign substances. Iron is one of these substances. The first reaction is absorption of the lime salts in the neighborhood of the iron in order to loosen the hold of the iron on the bone. This occurs even when there is no infection but in the presence of infection this process of absorption of the lime salts or osteoporosis is accentuated. There are, too, diseases in which so much demand is made for calcium in the body or in which there is such a deficiency of calcium that the bones are not properly supplied with this essential element. There are great variations in the power of different individuals to deposit lime salts in the repair of bone. In some apparently healthy and vigorous persons this tendency is very slight while in others and the majority of healthy individuals there is a marked tendency for a deposit of more callus than appears to be necessary.

The presence of iron, then, or any material that is irritating to bone, causes osteoporosis in its neighborhood. Infection produces at first softening of the bone because dilatation of the vessels and local leukocytosis cannot be so readily accomplished in the rigid tissues of normal bone as in soft tissue, and so nature tends to remove the rigid obstruction.

When an iron plate or iron screws are used in bone operations it has been frequently noted by careful observers that there is but little if any callus near the iron, and if union of the bone occurs it is by callus formation in that portion of the bone most distant from the site of the iron screws or plates. It seems a little strange, then, that in repair of bone, which can only be made by the deposit of calcium containing callus, a material is deliberately used which not only prevents the deposit of callus in its neighborhood but actually induces an absorption of the lime salts that were already there. In the usual provision by nature for much more callus than is necessary, this handicap in the repair of bone is often overcome and sufficient callus is thrown down in the part of the bone distal from the plate to make a union that is firm enough to remedy the weakness of the bone at the site of the plate. Occasionally, too, the callus may be so abundant as to limit the weakening influence of the metal to the immediate layer of bone with which it is in contact.

Bearing these facts in mind it is easy to see why the application of metal to bone is so frequently followed by nonunion. It is more difficult, however, to understand why, when these facts are known, metal plates are ever used. Even if the immediate repair appears satisfactory the patient is never free from the danger of complications as long as a heavy metal plate is fastened to the surface of the bone. Bone grafts taken from the same individual not only do not act as a foreign irritating substance, but actually encourage the local osteoblasts to produce callus and reconstruct bone.

In nonunion, the graft and the groove for its bed should be made sufficiently long so that the graft will touch healthy bone at each end. If it is too short the

exhausted and sclerosed bone in the immediate region of an ununited fracture will not be able to form a permanent union. If the bone grafting is done for a fresh fracture where there is no reason to suspect a deficiency in callus formation, the graft can be short and merely extends into the ends of the fractured bone sufficiently far to hold it mechanically in satisfactory position. Here the graft can be taken from the ends of the bone that is fractured, whereas in nonunion it is best to take it from a different bone or at least from a region remote from the fracture.

Cases are occasionally seen in which there is an unusually long, oblique or spiral fracture and in which the temptation to encircle the bone with a wire or with metal bands is great, as the mechanical union made in this manner seems very satisfactory. The same observations applying to metal plates and screws, however, apply to metal bands or wire that encircle the whole bone. A weak area is left where the bone is encircled, and occasionally there is a refracture later at this site. The cause of this refracture is that osteoporosis is established in an effort to throw off the irritating metal. Oblique fractures of this type most often occur in the femur and here the depth of the wound makes grafting somewhat difficult, and the obliquity of the fracture increases this difficulty.

Kangaroo tendon is an excellent material to hold in place a bone graft or to maintain an apposition in bone on which there is but little strain. I have fixed an oblique fracture of the femur in a small boy by encircling the femur in several places with stout kangaroo tendon, but the constant strain and cutting effect of the edges of the bone on the tendon caused it to give way in a few days. Here a small margin of the bone, no deeper than about one-third of the diameter of the bone, can be drilled through and a stout metal wire applied in two places. This does not interfere with the broad surfaces of the oblique fracture to prevent callus formation except within the small area within the grasp of the wire, and it is far preferable to encircling the whole bone with a wire or metal band, and gives as good immediate mechanical result.

No metal should be used in bone operations as a rule and the instance that I have just cited is an exception which only rarely occurs. Even here it would be well to have autogenous bone pegs, to fix the fractured ends, but as this would considerably prolong and complicate the operation the method described is probably better, as it is much shorter and simpler. As it involves only a small portion of the bone, the weakening should not be great enough to impair function.

A steel or iron plate should have no place in modern bone surgery. It not only inhibits callus formation and causes osteoporosis but is always a potential focus of infection, as it affords a focus where bacteria may be deposited from the blood, even if the operation has been done with every ritual that is recommended by the advocates of these plates.

The aseptic technic of bone surgery should be the same as that of any other surgery. The difference is that in handling bone with the gloved hands

the gloves are likely to be punctured and infection in this way may occur more readily than in soft tissue. The operator should use his common sense in this respect and handle the bone itself, particularly sharp portions, with heavy metal instruments, but there is no good reason why he should handle the soft tissues by this technic. Certainly the hand of a surgeon encased in a sterile rubber glove will do less damage to soft tissues than the crushing and laceration of heavy metal instruments.

If it has been determined that a fracture should be operated upon, because it is a compound fracture or because it is impossible to secure satisfactory adjustment of the fragments without operation, or because of nonunion or malunion, certain general principles should be followed in the operation; though there are variations which are necessary in order to meet the biologic needs of the particular case. If, for instance, it is deemed wise to operate upon a fresh fracture, all that is needed is to fix the fragments in a mechanical way by bone grafting or suturing and by external application of splints or traction so as to keep the fractured ends in proper position during the process of repair. In malunion of fractures it is necessary to mobilize the ends, to trim away the callus, and to reduce the fragments as nearly as possible to the condition they were in when the fracture was fresh. In nonunion, an entirely different problem is presented. Here the ends of the bone are most likely in contact or at least in good position but calcium salts have not taken part in the repair and the union is fibrous. The main indication is for some procedure that will so stimulate the bone forming elements as to induce bony repair.

In fresh fractures that are not compound but in which reduction cannot be accomplished without operation, there is a difference of opinion as to when operation should be performed. Some surgeons feel that it should be done immediately after receipt of the injury, others advise waiting until the second week after the injury, while a number of surgeons take an intermediate ground. Immediate operation will to some extent add insult to injury, and of necessity will cause greater swelling and more trauma than would follow the nonoperative treatment of the fracture. On the other hand, waiting until after two weeks means repair has already begun, valuable time has been lost, and much of the soft tissue in the neighborhood has become infiltrated and bound down by the callus. In the first forty-eight hours after an injury blood clots have formed and local leukocytosis has occurred. This means an added immunity against infection and makes operation somewhat safer than if done immediately after the fracture. The best time, then, for operating on fresh fractures is probably between the second and the tenth day after the injury. It is best to operate without a tourniquet, though a tourniquet should be available if unexpected and undue bleeding is encountered.

An incision in the skin is made of ample proportions so the bone can be reached without undue traction or injury to the soft parts. The margins of the wound are protected by towels fastened to the edges of the incision.

Whenever it is possible to do so it is best to carry the incision down to the bone through an intermuscular septum rather than through the muscle itself, though this cannot always be done.

When the fractured bone has been fully exposed in a fresh fracture the ends are reduced by manipulation with heavy forceps or long periosteal elevators having considerable leverage power. It can then be determined what is the best method of holding the fragments in position. In some cases an intramedullary graft will be sufficient. This can be secured from either end of the fracture by a chisel or a saw. A motor rotary saw is of great aid in this work and adds to the accuracy and shortens the time of the

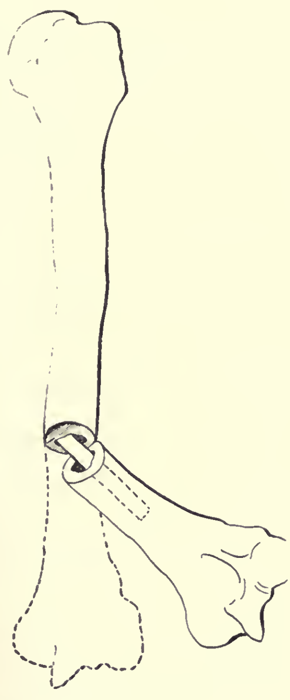

Fig. 94.—Placing an intramedullary bone graft.

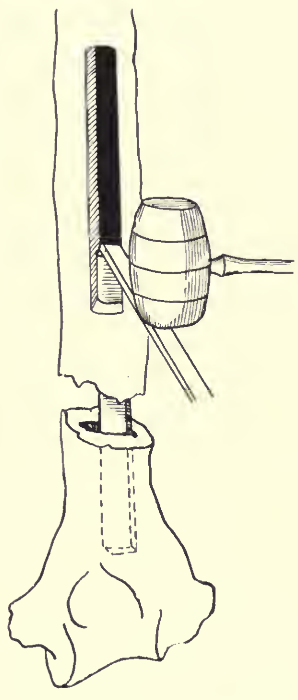

Fig. 95.—Hoglund's method of placing an intramedullary graft.

operation. The periosteum is first peeled back and a graft taken from either end of the bone about two or three inches long. It should contain the full thickness of the bone. It is not necessary to have periosteum with an intramedullary graft. The graft should be sufficiently thick to make firm bony contact with as much of the interior of the shaft as possible, though it should not fit too tightly as this may cause pressure necrosis. Sometimes a fragment from a fracture may be sufficient. The medullary cavity is cleaned out with a curet and a transplant two or three inches long is secured from the most convenient end of the bone. If a motor saw is used the transplant can be cut beginning about an inch from the end of the bone. This will leave an inch of the circumference of the bone at the point of fracture

intact. In this way more stability is obtained than if the graft were cut to the end of the fracture. The graft is fitted, as a rule, to the distal end of the fracture first and driven into the medullary canal lightly for about half of its length. The distal end of the fractured bone with the graft projecting from it is placed at an angle to the axis of the proximal end of the bone and so manipulated as to introduce the graft into the medullary canal of the upper end of the fractured bone (Fig. 94). The bone is then swung into its proper alinement. The method of Hoglund can often be used if a motor saw with parallel blades is employed. The graft is taken from one end of the fractured bone, beginning about an inch from the end, and is cut with parallel saw blades so the graft will drop into the medullary cavity. It is then driven down with a punch through the site of the fracture and sufficiently far into the medullary cavity of the other fragment so the fractured ends will be satisfactorily immobilized (Fig. 95). After closing the wound, suitable splints or a plaster of Paris support are applied.

In many instances, particularly in fresh fractures, the intramedullary graft

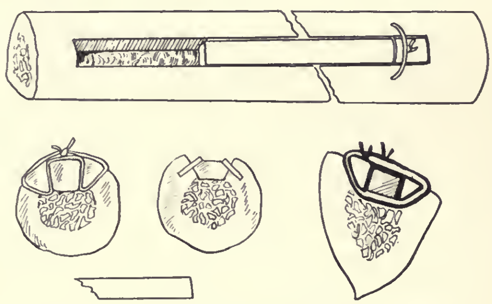

Fig. 96.—Albee's method of inlay bone grafting.

may be all that is necessary, but the inlay bone graft as developed by Albee[2] has many advantages, particularly in nonunion (Fig. 96). In fresh fractures if there is any reason to suspect that the callus will not be satisfactory the inlay method of Albee should be used. If the inlay method is employed the periosteum is not stripped back on the fragment from which it is proposed to take the graft, as it is best to have the inlay graft with periosteum attached. The incision must be generous and the exposure satisfactory without too strong retraction. In fresh fractures the graft can always be taken from the fractured ends. The strength of the graft should be sufficient to keep the bone in position, but it should not be made any larger than to fill this indication, for, as has already been pointed out, a small graft has more opportunity for nutrition than a large graft and consequently its osteogenetic powers are greater.

In small bones, as those of the forearm, it may be necessary to secure the graft from the tibia. By cutting an inlay graft much longer from one end of the bone than the other, it can be slid down and made to bridge the

[2]Albee, F. H.: Bone Graft Surgery, Philadelphia, 1915, W. B. Saunders Co.

fracture with about two inches of the bone graft on each side. The periosteum and endosteum in the grafts should not be disturbed. The graft is held in position by kangaroo tendons which are passed through drill holes along the edge of the groove in the bone, which is the bed of the graft, or the piece of bone made by cutting the short groove in one end of the fragments may be utilized in forming pegs, and these can be driven into drill holes that are made along the margin of the groove in such a manner as to hold the graft snugly in position. The bone is converted into these pegs by a doweling instrument, worked by the motor of the rotary saw. Each peg is from two to three inches long and will make from two to four fixation pegs. The doweling apparatus, or motor lathe, has the same diameter as the drill, so these pegs fit snugly and are cut off by the motor saw, leaving only a short portion projecting. If there are any fragments of bone left

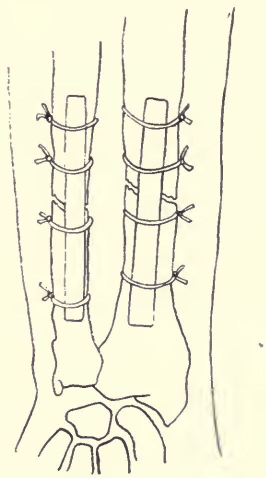

Fig. 97.—Inlay method of bone grafting of bones of the forearm.

they should be preserved and just before closing the wound placed around the ends of the fractured bone and about the graft at this point. Such small pieces of bone have a large osteogenetic power. In this way no foreign substance whatever is introduced into the bone but merely live bone which will serve to stimulate the local bone producing cells.

In small bones, such as those of the forearm, the graft can be held in position by kangaroo tendons which encircle the bone, at least two sutures being snugly tied over each end of the fractured bone (Fig. 97).

In malunion, the first problem is to reduce the fractures as nearly as possible to the condition in which they were soon after the fracture occurred. The medullary cavity in these cases is found blocked with callus. It is important that this be thoroughly cleaned out, not only because it is mechanically more difficult to unite the bone satisfactorily when the ends are solid, but because a greater tax on the local nutrition of tissues is made by the solid ends of the bone than if they are converted into cylinders. The cylinder ends,

too, are much stronger in proportion to their weight than the solid ends. After a malunion has been properly prepared the technic is the same as after a fresh fracture. If there is much shortening it is best to use the inlay graft of Albee, which can be so fixed as to bridge a defect if much bone has been lost, and will at the same time hold the fragments of bone in their normal axial position. It has been abundantly proved that a small fragment of bone which is made to bridge over a defect between the ends of the bone will gradually hypertrophy to the normal size of the bone which it unites. This is the application of Wolff's law, but, of course, the after-treatment should be so regulated as not to place too great a strain too suddenly upon the graft before it has had time to become strong.

The problem of ununited fractures shows that something besides accurate approximation and fixation is often necessary for the successful repair of fractures. A considerable proportion of nonunion of fractures occurs after the application of a steel plate, where the fragments are not only brought accurately into contact but are held mechanically immobile by the heavy iron plate and screws. The reasons for nonunion under such conditions have already been discussed, but they must be borne in mind in order to take the proper technical steps that will result in a cure of the nonunion.

Sometimes nonunion may be cured if the fibrous union is cut away, the ends of the bone freshened, the medullary cavity reamed out, the ends of the fractured bone made rough with rongeur forceps, the wound closed and the proper splint applied. Such a procedure will cause bony union in many ununited fractures. It is important to ream out the ends of the bone because an unnecessary amount of solid bone structure is thus removed which so takes away an unnecessary burden on the nutrition to the bones. The ends of the bone are made rough by cutting small bites with a rongeur forceps because in this way greater leukocytosis and more hyperemia is produced. Fixation by an external splint gives physiologic rest.

The inlay graft method of Albee will be followed more generally with success in nonunion of fractures than either the intramedullary graft, or the simple treatment which has just been outlined. The inlay technic differs somewhat in ununited fractures because the problem here is not so much to produce an accurate approximation as to stimulate osteogenesis. In an ununited fracture the ends of the bone are sclerosed, there is but little calcium, the bone is soft, and the osteoblasts have disappeared or degenerated. This process, as a rule, takes place to a greater extent in the distal fragment of the fractured bone than in the proximal fragment and it is necessary to secure a graft and to make a bed for the graft that will be sufficiently long for both ends of the bone graft to lie in contact with healthy bone tissue on each side of the fracture. In order to get out of the region of the sclerosed bone the graft should extend from two to three inches from the fracture on each end. This means that the length of the graft must be a minimum of four inches, or better, it may be five or six inches. Albee often uses the same technic as

in fresh fractures, only cutting the graft and groove with a motor saw much longer than he would in a fresh fracture because of the sclerosis.

If the graft is to be taken from the fractured bone it should be largely from the proximal fragment because of the greater sclerosis in the distal fragment. If the sclerosis is extensive, or if the bones are small, as in the bones of the forearm, it is best to secure the graft from the internal surface of the tibia. The graft is fastened in position by bone pegs or kangaroo tendons, as has already been described. The wound is closed by suturing lightly the fascia and muscles and closing the skin accurately but without tension. As these cases are usually supported by plaster of Paris, it is best to use absorbable catgut stitches in the skin so that there will be no need to remove the stitches.

In any repair of a fracture, whether it is a fresh fracture or nonunion, care should be taken to secure immobilization and usually traction. Nothing is superior to properly applied plaster of Paris. The dressing should be thin and the bony prominences should be protected by extra padding. The

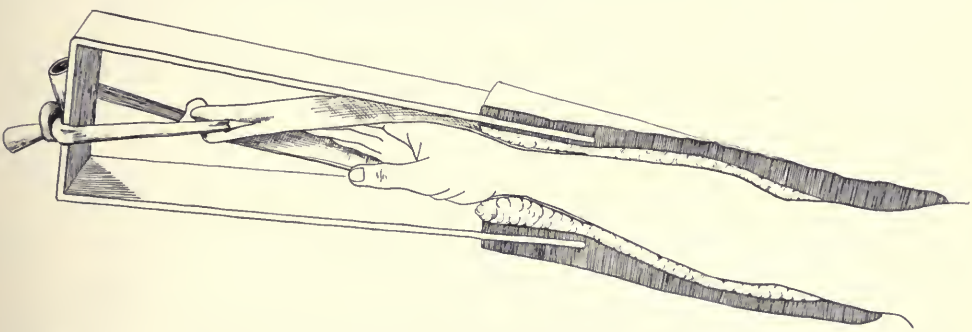

Fig. 98.—A method of extension that can be used after operation on the bones of the arm or forearm.

cast may be snugly applied if the patient is in a hospital where it can be promptly cut if there is too much swelling. When in addition to fixation, traction is necessary, it can be maintained by embedding into the plaster of Paris two strips of wood that project about six or eight inches below the lower part of the foot or the hand. Before applying the cast, adhesive plaster strips are placed on the limb as for a Buck's extension. The limb is well padded below the knee or the elbow and here the plaster is loosely applied if the fracture is above the knee or the elbow, so that the traction will be exerted on the fracture itself and not on the bony protuberances about the joints distal to the fracture. A small crosspiece of wood connects the two ends of the strips that have been embedded in the plaster of Paris. A rubber tube is passed through a perforation in the ends of the adhesive plasters that have been previously fastened on the limb. The rubber tube is tied over the cross strip of wood as shown in the illustration (Fig. 98). In this manner constant elastic traction is maintained on the limb without the necessity of weights or pulleys.

In operations for fractures of the femur or of the humerus, especially in mus-

cular individuals, some arrangement for traction is necessary, else the spasm of muscles will be so great as to make undue pressure and strain on the graft.

Albee's inlay method of bone grafting is applicable to many fractures besides those of the long bones. In fractures of the patella, for instance, if the excavation is cut with a straight groove connecting the two fragments of the patella and a transverse groove at each end, a graft can be so fashioned from the tibia as to fit in this groove and produce fixation of the patella.

In fractures or defects in the lower jaw the inlay method may be utilized by obtaining a graft from the tibia which may be made to bridge over a considerable defect as after partial resection of the lower jaw.

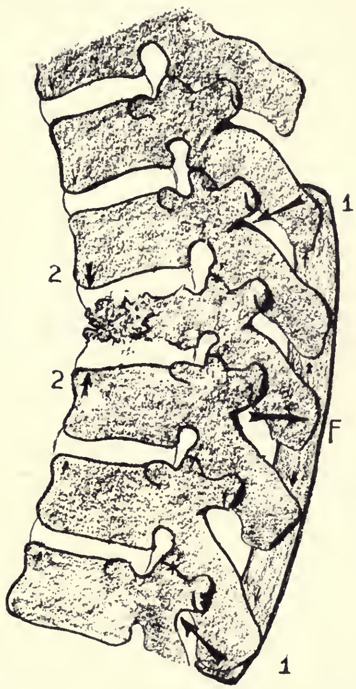

Fig. 99.—Diagram showing the action of bone graft in Pott's disease of the spine.

Albee has secured very gratifying results by the use of the inlay method in Pott's disease of the spine (Fig. 99). His technic[3] consists in making a sufficiently long incision with the patient prone, starting well above the diseased area, going to one side of the midline and coming back to the midline below the diseased portion. In this way a flap of skin is formed with its border well away from the midline so as to avoid pressure and to prevent the skin wound coming directly over the graft. After dissecting up the skin and its subcutaneous tissue the tips of the spinous processes and the supraspinous ligament are exposed. The supraspinous ligaments are split with a knife over the tip of the spinous processes and the intraspinous ligaments are also split,

[3]Albee, F. H.: Bone Graft Surgery, Philadelphia, 1915, W. B. Saunders Co.

taking care to avoid the muscle or the attachments of muscle to the spinous processes. With a broad, thin, sharp osteotome the spinous processes are split from a depth of one-third to two-thirds of an inch, and half of each

Fig. 100.—Albee's method of bone graft in Pott's disease of the spine. Spinous processes have been exposed and split, and a malleable probe is ready to be placed in the defect.

Fig. 101.—A malleable probe has been forced into the defect so as to present an accurate shape and size of the graft to be transplanted.

spinous process is fractured at its base and set open for a sufficient distance to make a groove large enough to receive the graft. All of the fractured halves of the spinous process should be on the same side. Bleeding points

are tied or compressed with gauze. The graft is obtained from the internal subcutaneous surface of the tibia. The groove for the reception of the graft consists of the split spinous processes and the cut supraspinous and interspinous ligaments with their osseous attachments undisturbed. This leaves the muscles and ligaments intact save for the split and fractured halves of the spinous processes (Fig. 100). The length and shape of the graft is determined by careful measurement with calipers and a flexible probe, which is applied to the gutter bed (Fig. 101).

With the patient in the same prone position the leg from which the graft is to be taken is flexed to an acute angle on the thigh and an incision is made along the inner border of the inner surface of the tibia. It should be so placed that the skin incision will not lie directly over that portion of the bone from which the graft is taken. The skin is dissected from the periosteum and the pattern of the graft is outlined on the periosteum by placing the molded probe on the periosteum and cutting the outline of the graft on the periosteum along the margins of the probe, just as a tailor cuts the cloth by laying the pattern on it and cutting along

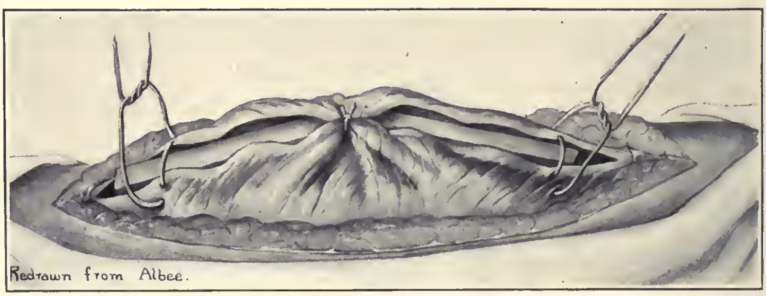

Fig. 102.—The bone graft has been cut, molded, and placed in position between the split spinous processes. It is being sutured in position with interrupted sutures of kangaroo tendon.

the edges of the pattern. If the graft is to be curved the two ends should lie posterior, so that the apex of the curve is at the crest of the tibia, which is the strongest part. A straight graft is obtained by cutting the cortex of the tibia through to the marrow cavity with a motor circular saw along the incisions in the periosteum that have already been made. A curved graft can be cut in a similar manner, using the motor saw. A molded graft is made by sawing, at regular intervals, partly through the surface of a straight graft and then bending the graft into the proper curve. This is best done by the motor saw, which has a guard so set that it will cut a definite depth and no deeper. The ends of the graft may be loosened by saw cuts made by a very small motor saw or by a thin osteotome. The graft is removed by prizing it up with a thin osteotome, taking care to preserve the attachment of the periosteum. A graft can be made with a chisel or hand saw, but the motor saw is far preferable. After removing the graft it is immediately transferred to its gutter bed and is held in place by strong kangaroo tendon sutures through the split halves of the supraspinous ligament (Fig. 102). The suture should be so adjusted as to secure a firm grasp on the ligaments and to

keep the graft firmly in position. At the points of fixation at the ends of the graft, sharp corners are removed by rongeur forceps and these chips are placed around the ends of the graft where it is in contact with the spinous process, before tying the sutures. Kangaroo tendon sutures are placed at intervals of about half an inch. If the graft is a curved one and not molded, the periosteum should lie on one side next to the spinous process and the endosteum on the other. The skin is closed in the usual way and sterile dressings are applied. It is important to prevent pressure on the graft, particularly if there is a marked kyphosis.

Albee's method of inlay grafts for Pott's disease of the spine is largely founded on the fact that the spine is made up of a series of levers, each vertebra being an individual lever with its fulcrum at the lateral facets. The anterior arm of the lever is the body of the vertebra and the posterior arm is the spinous process. In destruction of the vertebral body that portion tends to collapse, but by fixing the spinous processes at their extremities the strain of the pressure on the diseased body of the vertebra is taken up by the posterior end of the lever and the parts are put at rest (Fig. 99).

In the postoperative treatment the patient is placed on a fracture bed for five or six weeks with no other restraint than a towel across the chest, which is fastened to four strips of a broad muslin band, tied at each corner of the bed. If there is marked kyphosis abundant pads must be placed on each side to take up the pressure. No external fixation is applied to the spine during the convalescence except in unusual cases, where a light brace or plaster of Paris support may be worn for five or six weeks.

CHAPTER XIII

PLASTIC SURGERY

Plastic surgery is that branch of surgery which is concerned with correcting defects that result from trauma, disease, or errors of development. While in a broad sense it may be applied to operations on any kind of tissue, as bones, tendons or nerves, affected by trauma or disease, it is usually employed in reference to correction of defects involving the skin or mucosa either entirely or in a large part. Plastic surgery is chiefly concerned with the face though, of course, any portion of the body in which there are defects from injury or disease or from errors of development may be the subject of plastic operations.

The principles of plastic operations are concerned, first of all, with the nutrition of the corrected tissue, and, secondly, with a mechanical reconstruction that will bring the parts as nearly as possible to a normal condition. Operations that apply to particular regions will be discussed in the chapters devoted to regional surgery, but there are many underlying principles that must be borne in mind if success is desired in this branch of surgery, no matter in what portion of the body it is applied.

Plastic operations are of two types: that in which the margins of the wound are prepared for a fresh union and sutured without transplanting tissue or without the intervention of flaps, and that type in which flaps or grafts, free or pedunculated, are necessary. The former type is applicable in harelip and cleft palate or in defects that follow a small or narrow injury. Usually after burns or extensive traumas the resulting deformity is so great that it is impossible to reconstruct the tissues by excision of the affected part and union of the edges of the wound. In such cases several procedures are open. One is to undermine the margins of the wound for a considerable distance and determine if the additional elasticity obtained by the undermining will permit approximation of the edges of the wound. If this is impossible the raw surface can at least be diminished by sutures at the corners or angles of the raw surface.

Davis[1] has secured excellent results by gradual excision of the scar tissue. If a scar is too broad for total excision and approximation of the edges of the wound, an oval area is excised from the center of the scar and the edges of the wound are approximated. After this has healed firmly, which is from a few weeks to two months, another mass of the scar tissue is excised. In this way the elasticity of the skin will permit approximation of the healthy portion of the skin by gradual traction which would be impossible if all of the scar tis-

[1]Davis, J. S.: Plastic Surgery, Philadelphia, 1919, P. Blakiston's Son & Co., p. 212.

sue were excised at once. Often, however, even this will not suffice, for the defect or deformity is too great. In such cases, flaps or grafting must be resorted to.

The operation to be performed depends largely upon the part of the body affected and also upon the function of this region. If, for instance, there is a large raw surface on the back of the legs where a scar will not be conspicuous or annoying, the chief indication is to heal the raw surface even if there results a marked scar. It is always desirable to have as little scar tissue and as nearly a normal skin as possible, but if a large defect on the body or limbs can be so healed as to give the patient no discomfort and not to interfere with function, the main indication will have been fulfilled and it will hardly be justifiable to undertake prolonged and complicated operations to render the scar less prominent when a simple procedure will fill every other indication.

Plastic surgery chiefly concerns the face and the hands. Methods that not only restore function but remove deformity completely are chiefly desirable. Flaps of living whole skin with a pedicle usually give the best results from every standpoint. They should be matched with the texture of the skin around the defect as far as possible. As a rule, flaps taken from the margins of the deformity come nearer to corresponding with the texture of the skin in the region of the defect than flaps taken from some distant part. Esser[2] has called particular attention to this feature. Sometimes, however, it is impossible to obtain flaps at the defect and they have to be transplanted from a distance and the pedicle cut after the flap has been in position a sufficient length of time to obtain its nutrition locally.

A flap of the whole skin with a pedicle can often be obtained from the region of the defect with a view to remaining permanently in position. The flap should be so shaped that the pedicle will form part of the reconstructed field. A flap may also be obtained from distant portions, as from the arm, and allowed to remain in position for about two weeks. The pedicle is then cut. A free transplant of whole skin may be used if the defect is not too large. The whole skin method is called the Wolfe-Krause method. Wolfe insisted upon the removal of the subcutaneous fat. The subcutaneous fat in a transplant of whole free skin is of no advantage but probably an additional burden. J. S. Davis, of Baltimore, has developed this method quite extensively.

When the appearance of the scar is of secondary importance and the healing of the wound is the main object, thin grafts of epidermis, the so-called Thiersch grafts, are very satisfactory. When properly applied on a clean field such grafts usually take without trouble and large raw surfaces that would require months to heal or would probably never heal are closed in ten days or two weeks.

Thiersch grafts would be universally used instead of free transplants of whole skin or flaps except for two disadvantages; the scar resulting is conspicuous, for the skin of the scar does not appear to be normal, and there

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[2]Surg., Gynec. & Obst., June, 1917, pp. 737-748.

is often a marked tendency to contraction after the use of Thiersch grafts. This is particularly true if applied after a burn, and the reason is that in the Thiersch grafts nothing but the epidermis or the epithelial elements are used. The contraction after an injury to the skin of the face, for instance, is not in the epithelial elements of the skin but in the connective tissue that underlies the epithelium. In other words, the contraction lies in what corresponds to the corium, which is composed largely of connective tissue and on which rests the epithelial layer. If, in the healing process, this is made up of scar tissue, particularly of the dense scar tissue that follows a burn, contraction deformity will probably result even though the surface may be covered by healthy epithelium. It is contraction in this subepithelial layer that produces the striking deformities following burns of the face or hands with the eversion and twisting of the features, while contraction in the submucous layer causes the strictures of the urethra that follow ulceration. In all of these instances, the contraction is due not to the epithelial elements, which may be perfectly healthy, but to the connective tissue elements on which the epithelium rests.

If, then, a scar contraction is excised and Thiersch grafts are used to heal over the surface, the scar contraction will almost invariably recur beneath the Thiersch graft. In order to avoid this it is necessary to use the whole skin which contains not only the epidermis but normal healthy corium that does not contract.

Often incisions may be so made or flaps so shaped as to secure tissue from the neighborhood, which at first sight might seem impossible. Due regard must always be had for nutrition of flaps, and the pedicle should preferably be located in the general direction of the blood supply of the skin of which the pedicle is formed. The flaps should be handled as little as possible and as gently as possible. It must be borne in mind that unnecessary trauma not only destroys in a flap living tissue that might serve, but adds an extra burden to the blood supply which must absorb the injured cells and bring nutrition for repair of the defect left by their removal. In very vascular regions, such as the face, it is often possible to disregard the direction of the blood supply in making a flap because the blood supply is so abundant here and the collateral circulation is so great that a flap may be sufficiently nourished if the pedicle is large enough, even though the blood must come from the opposite direction of the normal blood supply.

Besides handling the flap gently and providing sufficient nutrition through its pedicle, care must be taken to insert the sutures in such a manner that too much tension will not be made. No matter how carefully the pedicle may be handled or shaped, if it is sutured so that there is too great tension, the blood supply will be obstructed and the flap will be partially or totally destroyed. Occasionally when tension in a flap is unavoidable, it is best to concentrate it upon one or two tension sutures that will produce pressure only in one place and relax the rest of the flap so there will be enough nutrition along the margins for satisfactory union. The nutrition of a flap may also be im-

periled by venous stasis. C. H. Mayo has often emphasized this point. Not infrequently the blood supply to a flap would be sufficient except that the venous return is imperfect and this blocks the capillaries which in turn prevent the feeble arterial current from being effective. In one instance in which I transplanted a flap from the forehead, preserving the temporal artery, the arterial nutrition of the flap was abundant, but gangrene of a large portion of it occurred because the venous return was not sufficient. Wherever a large flap with a narrow pedicle is transplanted this condition may obtain and should be carefully avoided. This is done by several short stab wounds in the substance of the flap and by leaving small gaps between the stitches along its margin through which the venous blood is emptied, so relieving the passive hyperemia.

Many of the procedures used to close defects have become almost classical. The chief methods are given in the accompanying illustrations, which are self-explanatory (Figs. 103, 104 and 105). The methods of Szymanowski are ingenious and usually satisfactory (Fig. 106). Often a simple relaxation incision parallel with the wound will be all that is necessary. An oval defect can be closed by any one of a number of different procedures. Lisfranc's method is simple and useful. In many instances the sliding of flaps not infrequently causes puckering, which is often conspicuous. This is eliminated whenever possible either by suturing or by incision of a triangular area that includes the puckered portion (Figs. 107 and 108). Oval, circular or quadrangular defects may be closed as shown in the illustrations (Figs. 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122 and 123).

If the flap cannot be carried to the affected part, which is done in defects about the face, the affected part can sometimes be carried to the flap, as when plastic operations are performed on the hands or on the lower extremities. Defects about the hand, forearm, or elbow, may be repaired by a flap from the abdomen, which is dissected up as a bridge of tissue between two parallel incisions and is left attached at each end. The defect on the hand is prepared for a graft and the hand is inserted under the bridge and the edges of the skin of the bridge of tissue are united to the margins of the wound on the hand by sutures. After about two weeks the flap is cut away. By making a flap with its broad base from the upper part of the abdomen the whole portion of the flap except its base can be sutured to the defect. In this way lesions of the palm of the hand are satisfactorily repaired and the patient is much more comfortable than when the hand is carried to the back.

When a pedicle must be cut, it is necessary to see that the flap is sufficiently nourished by its new location before severing the pedicle. When the pedicle is first severed the flap always becomes somewhat paler, but if the patient is young and in good health and the flap in good condition, a pedicle can usually be safely cut at the end of twelve days or two weeks. If in doubt, it is advisable to compress the pedicle with a soft clamp for an hour a day for several days before cutting it. In this way collateral circulation is developed.

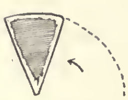

Fig. 103.—Closure of a triangular defect by the method of Jäsche.

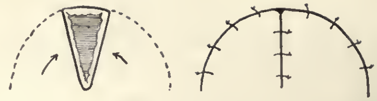

Fig. 104.—Closure of a triangular defect by the method of Szymonowski.

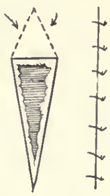

Fig. 105.—Closure of a triangular defect by the method of Ammon.

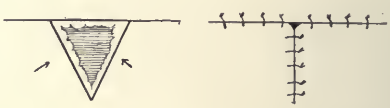

Fig. 106.—Closure of a triangular defect by the second method of Szymonowski.

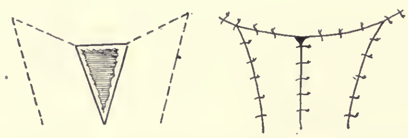

Fig. 106-*A*.—Third method of closure of triangular defect according to Szymonowski.

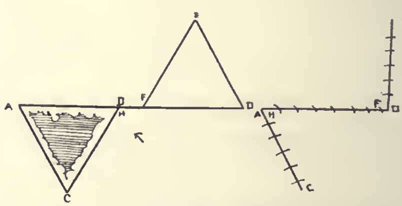

Fig. 107.—Closure of a triangular defect by the method of Burow.

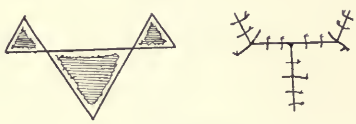

Fig. 108.—Second method of closure of triangular defect according to Burow.

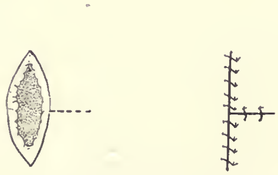

Fig. 109.—Closure of oval defect by method of Lisfranc.

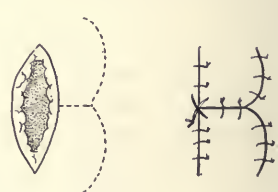

Fig. 110.—Closure of oval defect by method of Szymonowski.

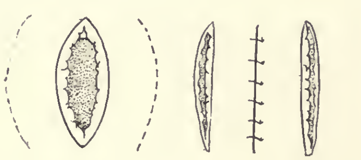

Fig. 111.—Closure of oval defect by method of Celsus.

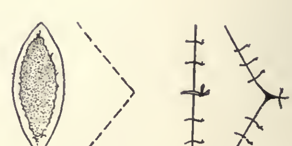

Fig. 112.—Closure of oval defect by method of Dieffenbach.

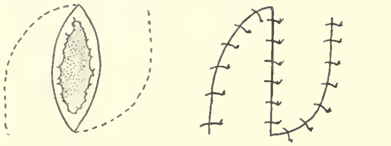

Fig. 113.—Closure of oval defect by double flap method.

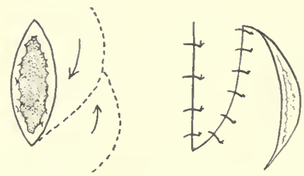

Fig. 114.—Closure of oval defect by method of Weber.

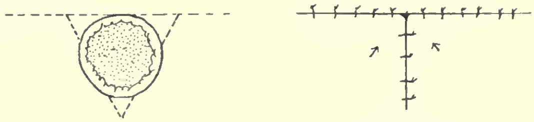

Fig. 115.—Closure of circular defect by first method of Szymonowski.

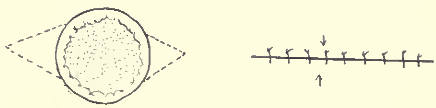

Fig. 116.—Closure of circular defect by second method of Szymonowski.

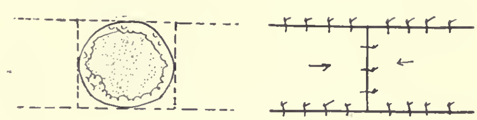

Fig. 117.—Closure of circular defect by third method of Szymonowski.

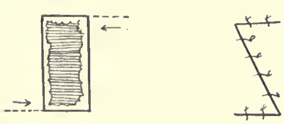

Fig. 118.—Closure of quadrilateral defect by method of Cole.

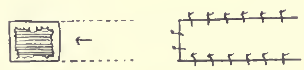

Fig. 119.—Closure of quadrilateral defect by first method of Szymonowski.

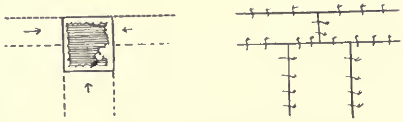

Fig. 120.—Closure of quadrilateral defect by second method of Szymonowski.

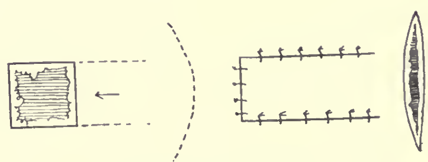

Fig. 121.—Closure of quadrilateral defect by method of Dieffenbach.

Fig. 122.—Closure of quadrilateral defect by method of Lexer-Bevan.

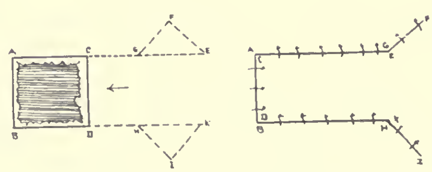

Fig. 123.—Closure of quadrilateral defect by method of Burow.

If it is desired to transfer a long narrow flap from the neck to a region on the face it is often too risky to imperil the nutrition by doing the operation in one stage. The nutrition from the pedicle of the flap, however, can be improved by first outlining the flap by incisions and then the bridge of tissue for the pedicle is undermined and separated by rubber tissue or some impervious dressing from the underlying raw surface. In this manner the nutrition at the two ends of the flap will be developed. The end that is to be severed is divided in sections at intervals of several days so that all of the nutrition will be gradually developed from that end of the flap which is to be the pedicle.

One of the most interesting and valuable principles in plastic surgery is

Fig. 124-*A*.—"Tubed" pedicle flap. The patient, a young boy, had a severe defect following noma, which resulted in the sloughing away of the cheek and a large portion of the superior maxilla. There was complete bony ankylosis of the lower jaw and he was fed through the defect. The illustration is a photograph which shows the defect and the "tubed" pedicle flap which was gradually dissected free at intervals of several days, so developing a blood supply in the pedicle.

the development of the blood supply from a comparatively small pedicle. In extensive reconstruction work about the face this is essential for success. "Tubing" of the pedicle, introduced by H. D. Gillies,[3] is a valuable aid in carrying out this principle. A flap is outlined from the chest and lower part of the neck of such a size and shape as may be best suited to the facial defect. The pedicle extends from just below the angle of the jaw to the main body of the proposed flap. It is about one and a half or two inches broad

[3]Surg., Gynec. & Obst., February 20, 1920, pp. 121-134.

and is raised over an extent of four inches or longer, depending upon the location to which the flap must be transferred. After dissecting the pedicle from its base to the margins of the proposed flap, the edges of the skin of the pedicle are sutured together with a continuous suture. In this way the raw surface of the pedicle is free from infection and also from the trauma and loss of blood which an exposed granulating surface is likely to undergo. The margins of the wound from which the pedicle has been dissected are undermined and united beneath the tubed pedicle so there is a minimum of raw surface exposed. About a week later one-third of the flap is dissected from its bed (Figs. 124 *A, B,* and *C,* and 125). If the flap is to cover part of the cavity of the mouth its raw surface is grafted with Thiersch grafts, or two flaps may be developed with tubed pedicles and one turned with the epithelial surface within the mouth and the other with the skin external. At intervals of

Fig. 124-*B*.—Photograph of the patient shown in the preceding illustration three months later. The flap from the neck had been turned with the skin side inward and the flap from the forehead with the skin side outward. The pedicles were severed after clamping the pedicles with soft forceps for half an hour a day for about ten days.

Fig. 124-*C*.—Photograph of the patient shown in the two preceding illustrations. This photograph was taken about seven months after that shown in Fig. 124-*B*. The ankylosis was overcome by the Esmarch operation and the lip was repaired by using the mucosa that extended on the left side up to the nose, the technic being similar to that of the Owen operation for harelip. The photograph shows the extent to which the mouth can be opened.

about a week the flap is again dissected in three stages covering a period of three or four weeks until it is entirely divided. This will develop a blood supply through the pedicle so the flap can be transferred without fear of insufficient nutrition. Sometimes, as recommended by Gillies, a large flap to cover an extensive defect of the face can be raised from the front and upper part of the chest by having two tubed pedicles, one on each side of the neck. When the pedicle is to be severed it can be either gradually cut,

severing about one-third at a time, at intervals of a week, or it may be compressed with a soft clamp or a rubber band for an hour twice a day for a week before being severed. In this way the blood supply is gradually thrown upon the new attachments of the flap in such a manner that the local nutrition is surely established, whereas a complete severing of the pedicle without preliminary preparation might result in such poor nutrition that the flap would break down (Fig. 126).

These principles of gradual development of the blood supply of a flap are exceedingly important in repairing an extensive defect and will enable deformities to be corrected much more satisfactorily than by the old method of a two stage operation in which the flap is completely dissected at one stage and the pedicle severed at another.

Fig. 125.—"Tubed" pedicle which has been Thiersch grafted on the raw surface and is ready to be turned into the defect in the face.

Fig. 126.—The flap with the tubed pedicle shown in Fig. 125 has been sutured into the defect in the face. A soft-nosed clamp is placed on the pedicle at intervals to develop blood supply to the flap.

"Jumping" and "waltzing" flaps may sometimes be resorted to. A flap may be turned, for instance, to the margins of the wound and kept there until the nutrition is well established. Then its pedicle is cut and turned over the defect; or a flap from the abdomen may be sutured into a wound made on the hand for its reception and, after it has taken, the pedicle to the abdomen is cut and the hand with the transplanted flap carried to the face. The flap is sutured into its new position, the pedicle to the hand being severed at the proper time.

Transplantation of whole skin is always desirable because of the better scar that results and the absence of contraction, but it is more difficult than Thiersch grafts, which consist only of the epidermis. In whole skin grafting the corium occupies relatively much more of the graft than the epidermis and consequently requires much more nutrition to keep it alive. The epidermis graft, which is the Thiersch graft, is very thin, has a large surface and small cubical contents, and consequently requires but little nutrition. The whole skin graft if reduced to many small masses, as in the Reverdin method, or the small deep skin grafts of J. S. Davis, can be used more successfully than if the whole skin is transplanted in one mass. However, this method, while promoting rapid healing, leaves a very conspicuous scar. In the small deep skin graft of Davis, not only is the epidermis taken but also a considerable portion of the corium.

Whenever skin grafts are used it is always best to take them from the patient. Autografts, as these are called, are much more likely to be successful than grafts taken from others of the same race, which are called isografts or homografts. Zoo-grafts are grafts taken from lower animals and invariably fail completely, though there may be an appearance of success at first.

Masson, of the Mayo Clinic, has had considerable success with isografts, when the donor's blood and that of the patient have been tested and proved to be of the same group. His results in using isografts when the red blood cells of the donor were agglutinated by the serum of the patient were always unsuccessful, but where this agglutination did not occur, the results were satisfactory. As a rule, however, it is always possible to get the grafts from the patient and no material can be more satisfactory than this.

The wound on which grafts are to be placed must either be a fresh clean wound or a healthy granulating surface. When the wound is fresh and clean Thiersch grafts will live whether placed on fat, fascia, tendon, muscle or bone. If the granulations are clean, firm, pink in color, and if the bacterial count from the wound secretion is very low or negative, grafts can be transplanted directly to such a granulating surface without any further preparation. If, however, the granulating wound is infected or if the granulations are too exuberant the wound must be prepared. This may be done by painting the granulations with tincture of iodine or by wet dressings of boric acid or salt solution. If, after treating the wound in this manner for a few days, satisfactory progress is not made, the patient can be given a general anesthetic, the granulating surface thoroughly painted with a tincture of iodine, and the surface cut away with a sharp knife. This is much better than curetting, which bruises and may force infection deeply in the tissues. Firm pressure with a dry gauze compress for at least five minutes usually controls most of the bleeding. Any special points that bleed at the end of this time may have a little longer pressure or may be sutured over with fine plain catgut. It is highly important that the surface to receive the graft should be

dry. The wound is prepared in this manner for the deep grafts of J. S. Davis, for Reverdin grafts, or for large whole skin grafts.

If the Reverdin method is used, pieces of epithelium are removed by sticking the point of a straight intestinal needle into the epidermis and shaving off the small piece of epidermis that is picked up by the needle. In using the method of Davis of small deep skin grafts somewhat the same technic is employed. Davis uses a straight intestinal needle held in an artery clamp. He has a series of these needles caught in clamps and picks up a bit of the skin, raising it so that a little cone is formed. The base of the cone is cut through with a sharp knife, going deep enough to secure not only the epidermis but the corium also. The graft while still on the needle is transferred to the wound, placing the raw surface next to the wound. A space of about one-fifth of an inch is left between each graft. They are laid in definite rows. When two rows have been placed they are covered by strips of dry, sterile rubber protective, which is pressed firmly over the grafts with a piece of gauze. The ends of the protective extend beyond the wound. The protective may be covered with gauze kept moist with salt solution, or a paraffined mosquito netting may be laid on the grafts and the latter covered with a dressing. Boric acid ointment may also be used. A moderate amount of gauze is placed over the wound and the part is immobilized as much as possible. It is best to keep the patient in bed for a few days. The first dressing should usually be done about the third day, but in a fresh wound without granulations it may be postponed until the fifth or sixth day.

The method of taking Thiersch grafts is to shave off the epidermis with a long sharp knife or razor. In order to do this the skin must be taut. Thiersch grafts are best taken from the thigh, the front, inner, or outer surfaces being used. The skin can be made tense by holding it with dry gauze on the upper part of the thigh, pressed firmly upward with the open hand of an assistant, while the operator with his left hand pulls down the skin of the thigh with dry gauze and with his right hand shaves off the grafts. If it is desired to take a large graft a long amputating knife or long knives made especially for this purpose may be used and it will be necessary to have the skin of the thigh flat. This is best accomplished by using two boards, the skin being held flat with one, at a point where the graft is started and the other being pressed just in front of the advancing knife. The knife should always be kept moist by solution dripping salt over it just before the graft is cut and during the process of cutting. Very large grafts can be secured by this method of using a long knife with two boards, which originated at Johns Hopkins Hospital. The graft, if it is smooth, is transferred directly to the wound for which it was intended and pressed into position by smooth moist gauze. The pressure should be firm and a slow rubbing motion is made over the gauze to cause the graft to adhere to the raw surface and to exclude air bubbles (Figs. 127 and 128). The grafts are laid as closely together as possible, preferably with the edges overlapping. If the graft curls up it may be spread out on several layers of smooth gauze, which has been wet in salt solution. It is

placed with the raw side up and with the finger it can be readily uncurled and spread out. It is then immediately transferred to the area that is to be grafted and pressed firmly into position. The gauze is gently removed, tak-

Fig. 127.—Two boards used to keep the skin tense while taking a Thiersch graft, according to the method of Johns Hopkins Hospital.

Fig. 128.—Thiersch graft is cut with a long amputating knife while the wooden boards keep the skin tense.

ing it up first at one corner. Usually the graft will adhere to the wound. If, however, there is any tendency for the graft to stick to the gauze, an

edge is loosened from the gauze with the end of a probe or mosquito forceps and held on the wound, and then the gauze can be removed, leaving the graft in place.

Some operators prefer to lay the grafts smoothly on a piece of rubber protective, spread over a board, and then transfer the grafts in this manner after enough has been cut to cover the whole surface. The raw surface of the graft should not dry and the sooner it is placed in contact with the wound the better. After the grafts are in position, if there are any bubbles caught under them in spite of the precautions to prevent this, they are nicked with the point of sharp scissors and pressure is made to expel the air.

There are a number of methods of dressing Thiersch skin grafts. Some surgeons prefer narrow strips of rubber protective. Silver foil also makes a good dressing, but it is likely to break up and if any of the grafts fail to take the silver becomes entangled in the granulations and may discolor the scar. The most satisfactory dressing for Thiersch grafts in my experience is sterile strips of zinc oxide adhesive plaster. Zinc oxide adhesive can be sterilized before the crinoline is removed by putting it in a steam sterilizer with the dressings. It is cut into strips about an inch wide and of a length to extend beyond the margins of the wound for about one inch. The strips are laid on carefully, beginning from the center and placed so that they barely touch each other and do not overlap. In this way drainage is provided. The strips must be applied carefully, for after they once touch the grafts the grafts will adhere to them and if the strips are not applied smoothly the grafts will be disarranged. After the wound is covered in this manner dry sterile gauze is placed over the adhesive and fastened in position by a snugly fitting bandage. The outer gauze dressing is removed three or four days later, as the serum from the wound makes the dressing stiff and may predispose to infection. The gauze dressing must be taken off carefully so as not to pull up the adhesive strips. The adhesive strips are removed about ten days after operation, when the grafts will have taken firmly. In this manner the numerous dressings and the necessity of moist gauze is done away with and at the same time advantage is taken of the fact that adhesive itself seems to stimulate epidermization. Boric ointment is applied for a week and then a dusting powder.

In certain instances where contraction is likely to be a chief feature the whole skin must be used. As has been said the deep skin or corium is the connective tissue layer and it is here that contraction occurs. Thiersch grafts being only the epithelium layer do not prevent the tendency to contraction in a wound where there is an excessive amount of scar tissue. The technic of using the whole skin graft, or the method of Wolfe-Krause, has been brought into considerable prominence recently by the excellent work of H. D. Gillies, of England and of J. S. Davis, of Baltimore. The method of preparing the field for the reception of whole skin grafts is similar to that for other grafts. All oozing must be checked and it is even more important to

stop bleeding here than when applying the Thiersch grafts. If the oozing of the raw surface cannot be stopped it is best to wait a few days before applying the graft. It must be remembered that the whole skin graft is several times thicker than the Thiersch graft and consequently requires a much greater blood supply for its nutrition. The whole skin grafts may be applied on healthy granulations which are level with the skin edges. If pressed firmly in position on the granulations no sutures are necessary.

The technic as given by Davis is to mark out lightly with the scalpel an elongated ellipse, which is considerably larger than the raw surface it is desired to cover, because the graft contracts greatly when separated. The graft is so shaped that the wound from which it is removed can be approximated by sutures without great tension. The skin and fat are removed down to the fascia. Fat is trimmed from the grafts with curved scissors and the grafts are perforated in several places with a knife or a saddler's punch to allow the escape of serum that may collect under the graft. It is best to secure the graft in position after pressing it firmly on the wound by four interrupted sutures and if necessary by a continuous suture of horse hair or silk. Sometimes the graft adheres so firmly that no sutures are required. It should be handled as little as possible and is placed in position immediately after it has been removed and prepared. The graft may be cut in the general size and shape of the wound but it is best to have it not too wide. It should not be more than one and one-half or two inches in width at its broadest portion. If a larger surface is to be covered a long strip of skin should be taken and cut into segments and the grafts laid side by side. Veins, if exposed, even though they are not injured, should be excised. Otherwise they may cause pain from thrombosis later on. It is much more difficult to secure success with a whole skin graft than with the Thiersch graft for reasons that have already been mentioned.

Gillies thinks it best to cut the graft in one piece and of the same size as the defect to be covered. In this way, he believes the skin is slightly stretched, the vessels are held open and the transplanted skin is kept at its normal tension. The graft is accurately held in place by sutures, and firm pressure made over it, for which he recommends dental wax. The graft is perforated with a knife in several places to give exit to serum. An adhesive plaster dressing, as described for Thiersch grafts is a good dressing for whole skin grafts. Abundant gauze and firm pressure must be used.

Whole skin grafts free should not be applied to bone or cartilage, because they require too much nutrition. Either Thiersch grafts or a whole skin graft with a pedicle should be used in such a wound.

About two weeks after the graft has thoroughly taken, gentle massage should be started upon it so as to soften the graft. In wounds where the normal skin is hair bearing a whole skin graft of this kind is made with the same technic that has just been described. A hair bearing graft can be taken from regions of the body in which hair normally appears, as the scalp or the

pubes. It can be shaped for an eyebrow and will prevent a conspicuous deformity when the eyebrow has been destroyed.

A graft transferred to bone, as on the skull, may not live if the wound is not very vascular or is extensive,. The wound should be prepared for the grafts a few weeks in advance by drilling through the outer table of the skull, a series of holes at close intervals. From these holes granulations will spring and upon them grafts can be laid. The granulations will furnish much more abundant nutrition to the grafts than would the undisturbed bone. This method has been developed and used successfully at the Mayo Clinic.

In plastic work where the whole skin free graft, or the pedicle graft, or sliding method is used a depressed scar along the line of union adds greatly to the deformity no matter how accurately the skin incision is made and sutured. If there is a depression and a groove the scar will spread and becomes very conspicuous. It is exceedingly important to prevent this. If there is the slightest tension and the sutures are improperly inserted, though the immediate effect may appear satisfactory, as healing and contraction takes place it will be seen that the scar becomes wider and is depressed.

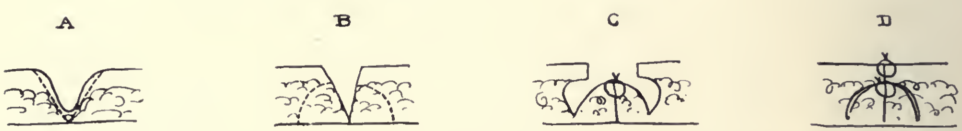

Fig. 129.—The method of Esser for preventing a sunken scar. The subcutaneous fat and fascia is so incised as to form a roll in the middle of the wound.

Esser[4] has laid particular stress upon this and calls attention to the importance of building up the underlying fat and fascia before suturing the skin. This may be done by inserting the sutures so as to catch a small margin of the skin and a deep bite of the subcuticular tissue on each side of the wound, thus approximating the subcuticular tissues firmly. If the tension is considerable or the desirability of an exceedingly small scar great, it is best to undercut the subcuticular fat and fascia on each side of the wound and bring the fat and fascia together by fine plain catgut sutures, so forming a slight ridge just under the line where the skin is to be sutured (Fig. 129). This procedure will make the line of incision apparently bulge a little, but as healing and contraction occur the ridge will disappear and the scar will be on the normal level of the skin instead of being depressed and contracted. This is a highly important point when excising any scar that has been depressed and is adherent to the tissues underneath. If the depression is too great to be corrected in this manner, there should be transplanted a small amount of fat, preferably on a pedicle from the undermined skin in the region of the wound, or, if necessary, a free transplant of fat from the thigh can be used.

[4]Surg., Gynec. & Obst., June, 1917.

CHAPTER XIV

OPERATIONS ON THE FACE AND MOUTH

Surgery of the face consists largely of either plastic surgery or the excision of tumors. The congenital defects of the face and mouth most frequently requiring operations are harelip and cleft palate.

Operations for harelip have an ancient and honorable history. There has not been the same change in technic that has occurred in abdominal and closed wounds where aseptic surgery can be practiced and where sepsis as a complication is avoided by the proper technic and after-treatment.

In operations on the mouth and lips no dressing can be applied. Much can be done, however, by preparing the mouth and lips and by treating the teeth for several days before the operation by careful cleansing with water and mild antiseptics. Of course the regular technic of aseptic surgery is followed, but particular care is taken to maintain the nutrition of the tissues, to make a sharp clean dissection wherever possible, and to avoid injury to the lines of the wound. As the wound cannot be sealed against infection from food or air, particular reliance must be placed upon these measures in order to maintain the resistance of the tissues against infection and their maximum ability for satisfactory and rapid repair.

The principles that underlie operations for harelip and cleft palate are those that have already been discussed in the chapter on Plastic Surgery. The parts must be mobilized as thoroughly as possible. An occasional drawn or unnatural fixation of the upper lip is due to the fact that the tissues were not thoroughly mobilized before suturing. Any operation on a harelip must be preceded by a dissection of the ala of the nose and the adjoining portion of the lip from the maxillary bone until the sides of the cleft fall easily in contact with each other without tension. The mucosa under the lip on the outer side of the cleft is cut with scissors or knife. The rest of the mobilizing dissection is done partly by spreading the blades of the scissors when there is little resistance, and partly by sharp dissection. A plug of dry gauze is inserted immediately after dissection and pressure is made to stop the bleeding. The pressure can be maintained by the fingers of an assistant until the bleeding has ceased. There is no occasion for any apparatus to clamp the lip in order to reduce the flow of blood from the coronary arteries. This is best done by the fingers of an assistant. The lip should not be pared until the operator is ready to insert sutures.

In incomplete clefts often a transverse incision which is sutured in the opposite direction from that in which it is made will give satisfactory re-

sults. This depends, however, upon the character of the lip. If the tissue just above the notch of the cleft is thin and poorly developed it will be much better to excise this tissue and convert the incomplete harelip into one extending into the nostril. The tissues should be cut widely enough to reach a lip of normal thickness. Nothing is more disfiguring than to unite thin tissue while on either side of the scar is a lip of normal thickness. Paring of the cleft is done with a view to securing a broad raw surface for apposition. If there is any doubt about this the lip is pared farther from the cleft until well developed tissue is found or else the pared wound is split with an incision so as to flare it open, turning the mucosa in and the skin out, and thus giving a wide raw surface for approximation. Such a procedure, however, is not often necessary.

The anesthetic is ether, given during the operation by pumping ether vapor through a bent, perforated metal tube which is placed in the corner of the mouth. Aside from the simple procedure of a transverse incision above the notch in the lip which is sewed up in the opposite direction to the incision there are a number of operations for harelip. This transverse incision can sometimes be made just below the nostril, as advocated by C. H. Mayo, and the scar will be less conspicuous than if made close to the margin of the mucous membrane. In spite of the multiplicity of more or less complicated operations for harelip usually two or three can be made to fill any requirement. The important points to be borne in mind are to approximate the tissues without tension, to have the vermilion border of the lip a continuous smooth line, and to have the lip at the line of incision slightly longer than normal to allow for subsequent contraction when the wound heals.

If there is a reasonable abundance of healthy lip tissue of normal thickness on either side of the cleft probably no operation is more satisfactory than the Rose operation or some of its modifications. The Rose operation requires a curved incision which is more difficult to make than an angular incision. After thoroughly mobilizing the lip an incision is made with a sharp-pointed knife from the apex of the cleft along the outer margin downward and outward to a point about one-eighth inch above the vermilion border. From the lower extremity of this incision another cut is made almost at a right angle to the first incision and going sharply inward and downward. The first incision is about one-eighth inch shorter than the length of the proposed upper lip. Similar incisions are made on the other margin of the cleft and the bleeding is controlled by pressure on the lip with the fingers and thumb of an assistant (Fig. 130). The incision goes well through the skin and down to the mucosa. It is difficult to cut the under surface of the mucosa smoothly with a knife and this part of the incision can best be finished with sharp scissors. A tractor suture of fine silkworm-gut is inserted into the lowest portion of the mucosa of the lip. This suture is not tied, but the ends are left long and clamped with a mosquito forceps. It is used as a tractor suture and by gentle traction the rest of the lip is thrown into easy apposition. A suture of fine silkworm-gut is then inserted, beginning close to the margin of the wound

and at the angle made by the junction of the two incisions. The insertion of this suture is exceedingly important. It is made with a small sharp needle, preferably a curved needle, and the suture, after penetrating the skin close to the wound, goes well out into the tissues of the lip and then comes back taking a small margin of the mucosa. The bite this stitch takes in the mucosa is important. If it catches the mucosa too far toward the nostril it will force the vermilion border to the lower end of the skin incision; consequently, the mucosa should be caught near the lower portion of the wound to prevent the forcing of a redundant amount of mucosa toward the skin part of the incision. This suture is carried over to the other side and inserted in a similar manner, only it goes from the mucosa to the skin, taking care on this side also to catch the mucosa at the proper place near the lower end of the incision, to take a large bite of lip tissue and a small bite of skin. It emerges at the angle made by the two incisions. This suture is tied snugly but not too tightly and the ends

Fig. 130.—A modified Rose incision for a single harelip.

Fig. 131.—The sutures have been placed and all are tied except the tractor suture.

are left long until the next suture is applied. The third suture, also fine silkworm-gut, is placed near the nostril and penetrates the whole thickness of the lip. The next suture unites carefully the vermilion border of the lip. This is done while making traction on the tractor suture. This suture may be of silkworm-gut or fine silk, preferably arterial silk. As many other sutures of fine arterial silk are inserted as is necessary to secure satisfactory approximation. The stitches in the skin are placed first, then those in the mucosa (Fig. 131). Lastly, the tractor suture is tied, if tissues which it embraces have not been too much damaged by the traction. If so, sutures of fine arterial silk are inserted near the tractor suture to maintain apposition of the mucosa and the tractor suture is removed. The nostril should be approximated accurately. Sutures are often carried too far into the nostril and so occlude it. The nostril should be made symmetrical with the normal nostril, but it is better to have it flare open slightly, a defect which can be easily remedied by a subsequent

stitch, than to have it too tight, as this is much more difficult to correct. Allowance should always be made for contraction along the line of scar and the lip should be made slightly longer than appears to be normal.

If the tissues in the neighborhood of the cleft are quite thin and too much tension would result if thin tissues were entirely sacrificed, the Owen operation can be done. This operation is also indicated when the cleft of the harelip is

Fig. 132.—An incision for harelip according to the method of Owen.

Fig. 133.—Sutures in the vertical incision of Owen are placed.

Fig. 134.—The last sutures are placed in the operation of Owen.

unusually wide. The method of procedure is best indicated in the accompanying illustrations. The lip is well mobilized as already described. The outer margin of the cleft of the harelip is pared from the nostril to the corner of the mouth, the incision making a decided angle at a point about halfway between the nostril and what would be the vermilion border of a normal lip. The incision on the other side of the cleft begins at the nostril and goes downward along the

cleft to about opposite the angle of the incision on the outer side, then it turns transversely away from the cleft, ending about midway between the normal nostril and the lower border of the upper lip (Fig. 132). A suture for fixation is inserted in such a manner that it brings together these two incisions just at the point where they turn outward from the cleft of the harelip (Fig. 133). A second fixation suture unites the tip of the flap containing the mucous membrane to the corner of the mouth. The nostril is approximated by a third fixation suture and the rest of the wound is closed by interrupted or continuous sutures of fine silk or horsehair (Fig. 134).

Double harelip is often accompanied by a prominent intermaxillary bone. In such instances, it will be necessary first of all to replace the intermaxillary bone, which should never be cut away. This is done by making a submucous resection of a part of the septum which supports the intermaxillary bone. An incision is made along the lower border of this septum, the mucosa is stripped up on each side and a sufficient amount of the septum is cut away with scissors or bone forceps to enable the intermaxillary bone to be pressed into position between the two maxillary bones (Fig. 135). The outer edges of the inter-

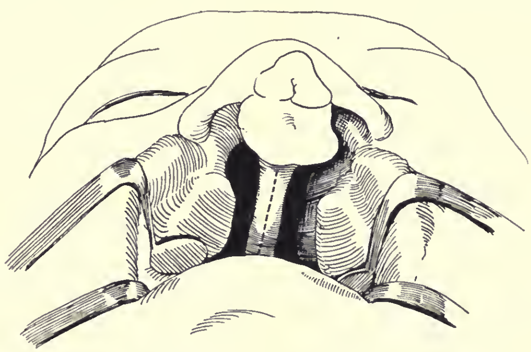

Fig. 135.—Line of incision for excision of nasal septum.

maxillary bone are pared with a sharp knife and the corresponding sides of the maxillary bones are similarly freshened. The lip on the outer sides of the cleft is freely dissected from the maxillary bone. With a stout perineal needle, with the eye at the point, in infants, or with a drill in older children, a hole is made about one-fourth to one-half inch from the margin of the cleft above the alveolar process and through the maxillary bone into the mouth, coming out about the junction of the hard palate with the alveolar process. The direction of the perforation is slightly downward, as well as inward and backward. In this way a good hold is obtained on each maxillary bone and at the same time the matrices of future teeth are uninjured. A wire is passed through these perforations. If a perineal needle is used the wire is threaded into the eye of the needle as it appears in the mouth. A moderately stout bronze wire may be used, though braided or cable bronze wire is preferable and is easily tied. One end of the wire is carried across the front surface of the intermaxillary bone with the perineal needle, going just beneath the lip tissue that covers this bone. The bone is pressed into position and the wire adjusted accurately either by twist-

ing, if it is solid wire, or by tying, if it is braided or cable wire. The double harelip can then be repaired or this can be done at a different sitting.

The intermaxillary bone should not fit too far into the defect that exists between the anterior portions of the maxillary bones because it will pull the nose down too low, and also because the intermaxillary bone will gradually be pressed further in after the double harelip is repaired.

If there is a marked cleft of the alveolar process and hard palate in an infant with single harelip, an effort should be made to close the front of this cleft in a somewhat similar manner before repairing the harelip. The wire is inserted as has just been described and is twisted or tied while the margins of the cleft in the alveolar process are forced together by the hands of an assistant on each cheek. In this way the anterior part of a cleft in the hard palate can be brought together or greatly reduced, and a single wire suture thus placed will secure much of the benefit without the added danger that is derived from multiple wire sutures inserted farther back through the cleft.

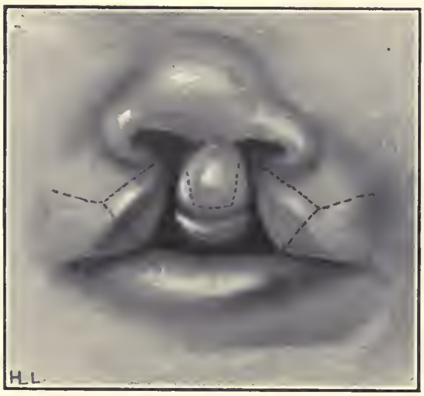

Fig. 136.—Lines of incision for double harelip.

Fig. 137.—Double harelip operation completed except for insertion of additional sutures.

Practically all double harelips can be repaired by a slight modification of the operation for single harelip. The only differences are that the margins of the lip on the intermaxillary bone are pared to make a broad wounded surface and an outward relaxation incision of about one-fourth inch is made from the angle formed by the meeting of the two incisions used for paring the margins of the cleft, as has been described under single harelip (Fig. 136). In this way two flaps consisting of the vermilion border of the lip with the adjacent skin are mobilized and can be readily sutured together just under that part of the lip on the intermaxillary bone. Fixation sutures are placed at each nostril and also at the points connecting the lower margins of the lip on the intermaxillary bone to the adjacent portions of the pared lip (Fig. 137).

After repairing a double harelip in this manner the columna is markedly pulled down by the new position of the intermaxillary bone so that the tip of the nose is drawn forcibly down to near the level of the lip. There is a great

temptation to correct this by an immediate operation on the columna. Blair, however, has called attention to the fact that the columna will gradually lengthen and release the tip of the nose and that such operations are usually unnecessary, particularly in infants.

Fig. 138.—David R., ten months old. Photograph taken before operation.

Fig. 139.—David R., shown in Fig. 138. Photograph taken four months after operation. The patient also had a complete cleft of the palate which was cured by operation.

Fig. 140.—Bessie H., three weeks of age. Hare-lip and complete cleft of palate.

Fig. 141.—Same patient shown in Fig. 140. Photograph taken two years and seven months after the operation. Palate had also been closed by operation.

No dressing is placed upon the wound which is merely dusted with boric acid powder. This becomes incorporated with the serum, hardens and forms a protective sealing. The tension on the harelip is largely taken up by the fixation sutures and no appliance to relieve tension is necessary. The fine stitches

are removed after four or five days. The fixation sutures, however, should not be removed under seven or eight days and unless the wound is quite firm may be left even longer. While less scar from the stitches occurs if they are removed soon, the tissues need the support of the stitches and will stretch unduly without them, so that the scar along the line of incision will be made more conspicuous if the fixation sutures are removed too soon (Figs. 138, 139, 140, 141, 142 and 143).

There is much discussion as to the age at which harelips and cleft palates should be operated upon. A harelip should be corrected early. If the baby is vigorous it may be done even a few hours after birth. When the baby is two or three weeks old, however, seems to be almost an ideal time. If a cleft palate extends through the alveolar process the anterior part should be cor-

Fig. 142.—Herbert T., age seven months. Double harelip and cleft palate.

Fig. 143.—Same patient shown in Fig. 142. Photograph taken two years and three months after operation.

rected at the same time the harelip is repaired. This will greatly narrow the cleft. The rest of the cleft can be repaired from two to six months later if the patient is in good condition. None of these patients should be operated upon until their general health has been brought up as much as possible. The harelip patient should be examined a few months after the operation. Not infrequently a slight irregularity of the lip will then be noticed, which was not apparent immediately after healing. The contraction in the line of the scar may be unduly great and may produce a slight notch or sometimes one side will pull up where it has been mobilized and elevate the vermilion border. All of these changes will occur within a few months after the operation and they can be readily remedied by a simple procedure which will make the lip practically normal. If the mucosa of the lip has pulled up into the incision this can be corrected by the excision of a small, broad, diamond-shaped area, so planned and sutured that the excess of mucosa is removed and the margins of the skin

are brought together in such a manner as to make the vermilion border of the lip continuous and straight. The sutures used are fine arterial silk or horsehair. If the skin on one side has pulled up more than on the other, excision of the triangular redundant portion of the mucosa with a slight extension of the incision upward along the line of the old skin incision, and undercutting the skin in the neighborhood will enable the defect to be corrected by drawing the skin to its normal level. All these defects should be somewhat overcorrected.

CLEFT PALATE

The great majority of cleft palates can be repaired by adapting the flap sliding principle of plastic operations. This, the Langenbeck operation, has been developed and emphasized by Berry and Legg and by Blair who have obtained excellent results. It is particularly applicable in clefts with a high arch. It undoubtedly comes nearer returning tissue to their physiologic normal than complicated plastic procedures in which flaps are inverted, such as the method of Lane.

The anterior portion of a cleft in the hard palate in an infant or a young child should be closed or diminished as much as possible while the bones are soft by the insertion of a single wire suture as described under operations on harelip. If a harelip is present this wire is placed before repairing the harelip. The whole cleft in the bony palate, and particularly that in the front part, is greatly diminished by this single wire suture. It seems to accomplish most of the good that is obtained by the multiple wire sutures and is followed by less danger of necrosis than when multiple wire sutures are applied.

The operation of Lane in which a wide flap is taken from one side of the cleft with the hinge on the margin of the cleft and turned over and into a pocket made by dissecting up soft tissues on the opposite side of the cleft, at one time had many advocates. There are serious objections to this operation, however. It exposes a large amount of raw surface and is, consequently, followed by extensive scar tissue. While union is more likely to occur after such an operation than after the flap sliding operation of Langenbeck as advocated by Berry and Legg, the late results are frequently unfortunate and the excessive scar tissue, while closing the actual cleft, probably functions but little better than would a rubber obturator. The late results of the Lane operation, at least in my hands, have not been satisfactory so far as obtaining good functional use of the soft palate is concerned.

The difficulties in using the Langenbeck flap sliding operation are in cases with a low palate arch and those with a wide defect. In such instances, however, as has been shown by Blair, much can be accomplished by making an incision in the hard palate just internal to the alveolar process, stripping up the mucoperiosteal flaps from the bone, and separating the attachment of the soft palate to the bony palate as though a complete palate operation would be done, but instead of paring the edges of the cleft and placing sutures, these incisions are packed with gauze saturated in ten per cent solution of colloidal

silver and stitched in place. After doing this Blair advocates operating four days later at which time there is a maximum amount of approximation of the flaps. If the operation is still further postponed shrinkage of the flaps will occur.

Probably the best suture material for cleft palates is fine silver wire No. 29 or No. 30. This can be inserted with fine curved needles held in the tip of a hemostat or a small needle holder. If the needles are sharp they can be manipulated satisfactorily. The advantage of silver wire is that it is mildly antiseptic and so tends to prevent infection, which is the bane of cleft palate work, and also it can be very accurately adjusted. It is, of course, impossible to use coarser silver wire for such work, but the fine wire can be accurately twisted and if a suture appears too tight it can be relaxed, while if it is not tight enough it can be tightened by an extra twist. Mosquito forceps are very useful in this work. These and a sharp-pointed knife, together with a periosteal elevator, one end of which is bent at a right angle, are the chief instruments that are needed.

The patient is placed with the head well back and in a good light. The tip of each half of the uvula is caught with a mosquito forceps. One side is held taut and with a sharp-pointed knife the mucosa at the front angle of the cleft, if it is not a complete cleft, is transfixed and a thin ribbon of tissue is cut off from this point to the tip of the uvula. The same procedure is repeated on the opposite side. An incision is then made just internal to the posterior portion of the alveolar process of the upper jaw. This hugs the alveolar process closely and is extended slightly around its posterior portion. In this manner the descending palatine artery is avoided and the nutrition of the flap, which is essential to successful union, is preserved (Fig. 144). A small periosteal elevator is inserted into the incision and the mucoperiosteal flap is raised. This is done as gently as possible so as to separate the tissues without too much injury to the flap. The tip of the elevator is pushed through to the cleft and is carried by a rocking motion, first forward and then backward to the soft palate. It is very important to separate the attachment of the soft palate to the bone of the hard palate. This is best accomplished with curved scissors, injury to the soft palate and the mucoperiosteal flap being prevented by retraction of this flap with a hook or with the tip of the finger. Division can also be made with the tip of a sharp knife which cuts from below upward. Sometimes the division can be made by curved scissors through the relaxation incision. It is vital for the success of the operation that this attachment be thoroughly separated.

The sutures are now placed, inserting the first suture about the point of junction between the soft palate and the mucoperiosteal portion of the hard palate. This suture of fine silver wire is not tied but the two ends are clamped and aid in exposing the margins of the cleft for further sutures. Three or four other sutures are placed in the soft palate and as many more anteriorly. They may be twisted as they are placed. At the tip of the uvula a suture is twisted and cut. Sometimes the sutures are more easily placed by having a needle on

each end. It is highly important that the sutures approximating the edges of the wound should not be under tension. If the general tension appears too great the original relaxation incision should be continued either forward or backward and the flaps more thoroughly mobilized (Fig. 145). It may occasionally be wise to insert one relaxation stitch in a large curved sharp needle about where the soft palate joins the mucoperiosteal portion of the hard palate. This should be of silver wire and twisted to one side of the wound. This suture is very infrequently required and diminishes the nutrition to the margins of the wound.

The ends of the wire are cut and are left slightly protruding. In this way the wound, particularly in infants, will be protected from the tongue. The mouth should be systematically cleaned for some days before operation but it is doubtful if the application of any antiseptic at the time of operation is

Fig. 144.—Lines of incision for relaxation in the operation for cleft palate. A ribbon of tissue is being cut from the margins of the cleft.

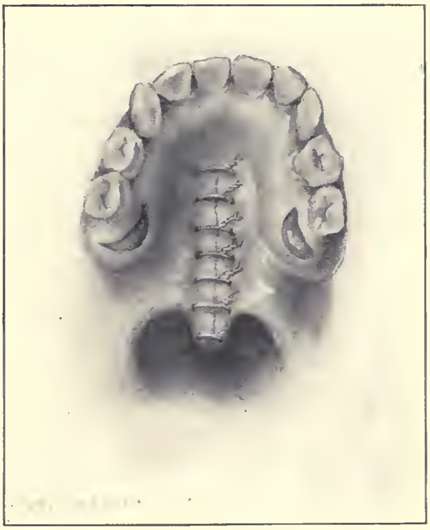

Fig. 145.—Cleft palate operation completed.

beneficial and it may be irritating. The anesthetic of ether is maintained by a curved metal tube, which is placed in the corner of the mouth while ether vapor is sprayed through the tube. This also has an antiseptic value.

If the cleft is complete and the bones are too well developed for the anterior portion to be closed by a wire suture, this portion is left for a subsequent operation, because if too much is undertaken at first the nutrition of the flaps will be imperiled. After about four weeks the anterior portion of the cleft is repaired by turning over a limited flap after the general method of Lane. In this portion of the cleft, where the only function of the palate is to act as an obturator, there is not the same objection to the operation of Lane as in the posterior portion where muscular action is essential for the proper functioning of the palate. Here a pocket is created by undermining one side of the cleft from an incision along its edge. A flap is taken on the op-

posite side with its hinge along the margin of the cleft and is turned over and tucked into the pocket and fastened in position with sutures.

If a cleft is so wide or the arch so low that the flap sliding method of Langenbeck cannot be applied, the Lane operation may be attempted. If the patient is an infant and the teeth have not erupted a wide flap can be obtained from the buccal mucosa and the alveolar process. In older patients with teeth, a flap from the anterior portion of the buccal surface of the cheek is impossible, but a flap may be turned down from the mucosa with a pedicle posterior to the alveolar process or, as practiced by Blair, a flap may be taken from the neck, carried into the mouth between the teeth, and fastened across the cleft. A permanent gag is placed between the teeth to prevent injury to the flap, and after a few weeks when the nutrition of the flap is established in the mouth the pedicle is severed. The cleft is closed by the transplant after a series of readjustment operations.

THE LIPS

Surgery of the lips consists largely of plastic surgery. Operations for congenital deformities have already been considered. Plastic operations on the lip may be for acquired deformities, either from accidental trauma or from removal of malignant disease. Operations for cancer should be planned

Fig. 146.—Lines of incision for repair of upper lip by method of Denonvilliers.

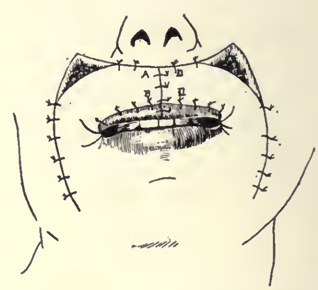

Fig. 147.—Operation of Denonvilliers completed.

primarily with a view to curing the cancer and the cosmetic effect should be a secondary and a different consideration. Halsted has observed that if the surgeon who operates for cancer did not attempt to close the defect, but left this for someone else, all temptation to leave conditions favorable for a closure of the wound would be removed, more cancers would be cured, and plastic operations after removal of cancer would fall into the same general category as accidental trauma.

The upper lip is rarely the site of malignant disease, whereas cancer of the lower lip is common, so reconstruction of the upper lip aside from congenital deformity is called for usually on account of accidental trauma. A very satisfactory operation for reconstruction of the upper lip is that in which flaps are taken on each side, either extending upward with the base downward, according to the method of Denonvilliers, or extending downward with the base

upward according to the method of Sedillot. The method of Denonvilliers consists of two vertical flaps that are made through the full thickness of the cheek with the pedicle below (Figs. 146 and 147). The external incision extends from the lower border of the jaw to the level of the ala of the nose and the internal border of the flap is the margin of the defect in the upper lip. A transverse cut is made to loosen the flap, which is turned down and sutured in the midline beneath the nose. The mucous membrane lining the flaps, must be arranged to form the vermilion border. The flap contains the whole thickness of the cheek. In the operation of Sedillot the flaps are reversed, taken

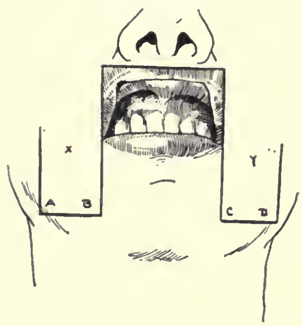

Fig. 148.—Operation of Sedillot for repair of the upper lip.

Fig. 149.—Lines of incision for repair of defect in upper lip by method of Abbe.

Fig. 150.—The flap from the lower lip has been turned into the defect in the upper lip, according to Abbe. The flap is kept in this position for about two weeks, when the pedicle is cut.

Fig. 151.—The pedicle has been cut, and the operation of Abbe completed.

with the base above. These flaps are turned upward and inward and the vermilion border is made along the lower margins of the flaps (Fig. 148).

The upper lip may be constructed from hair-bearing tissue by taking a long flap from the temporal region which includes the scalp and turning it down. A similar flap is taken from each side and the pedicle cut after the local nutrition seems to make the flap viable.

In asymmetrical deformities of the upper lip, the general principles of plastic work, which have already been discussed, can be applied. If there is too great contraction of the upper lip the method of Abbe may be utilized and a pedicle flap turned up from the lower lip. According to this method, the de-

fect in the upper lip is prepared and a flap from the lower lip with the pedicle on one side (as shown in the illustrations) is turned up and sutured in position. The lips are held together with sutures and the patient is fed through a tube for twelve or fourteen days, when the pedicle is cut. This is a very valuable method, particularly when the lower lip is somewhat redundant (Figs. 149, 150 and 151). Gurdon Buck's operation involves the same principles, but a more extensive flap is taken, involving probably a third or even half of the lower lip and including the angle of the mouth (Figs. 152 and 153).

In any operation upon the lip, particularly upon the upper lip, it is necessary that the internal surface have a satisfactory lining, preferably of mucosa. If this is not possible a lining may be made with skin by a flap turned up from the neck. If the raw surface left within the mouth is very extensive, contraction is sure to occur and so much scar tissue may involve the flap that a secondary operation will be necessary later. If possible, a flap of mucosa from the

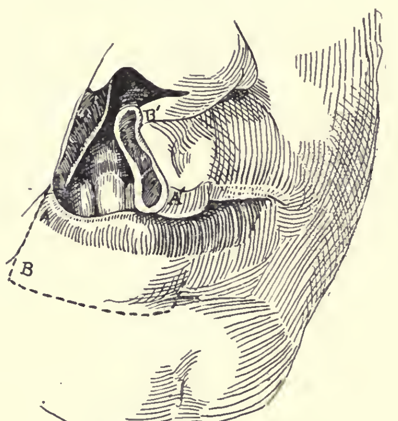

Fig. 152.—Lines of incision for the operation of Gurdon Buck in repair of the upper lip.

Fig. 153.—Operation of Gurdon Buck completed.

tissues in the neighborhood should be utilized to line the skin flaps. Contraction will be less marked in well-established tissue from which the mucosa flap is taken than in the raw surface of the new flap if left unprotected.

The lower lip may be reconstructed from flaps in its neighborhood or from flaps from the arm. The lower lip is frequently the site of cancer and reconstructions are often necessitated by operations for this disease. The simplest method of removing cancer and reconstructing the lip after its removal is by the V-shaped excision. If the cancer is extensive this method cannot be used, but in many early cases of cancer the V-shaped excision is entirely satisfactory. Care is taken to keep a safe distance from the margins of the cancer. The cancer should be cauterized with a thermocautery just before the operation, in order to avoid the possibility of transplantation of cancer cells. The incision is made so the V will be deep and not too shallow (Figs. 154 and 155). This results not only in a more extensive removal of tissue, but at the same time the closure of the wound is more satisfactory. The incisions are made

through the skin and down to the mucosa. Two through-and-through sutures of silkworm-gut are inserted, one just below the vermilion border and one farther down. The loops of the suture are held out of the way, the mucosa is quickly cut and the lip is approximated. In this way not only is bleeding lessened, as it can be controlled satisfactorily by the sutures, but there is a minimum exposure of the wounded surfaces to the secretions of the mouth. The rest of the incision is accurately approximated with interrupted sutures

Fig. 154.—V-shaped excision for cancer of the lower lip.

Fig. 155.—V-shaped incision closed with sutures.

of arterial silk or horsehair for the skin, and arterial silk for the mucosa. By making a transverse incision at each corner of the mouth, the V-shaped incision can be applied in a much larger number of cases and this may be combined with the Burow-Stewart principle of excising a triangle of tissue down to the mucosa just above the angle of the mouth on each side (Fig. 108). In this manner a considerable portion of the lower lip can be removed with comparatively little deformity.

In extensive cancer of the lower lip the operation of J. Clarke Stewart is

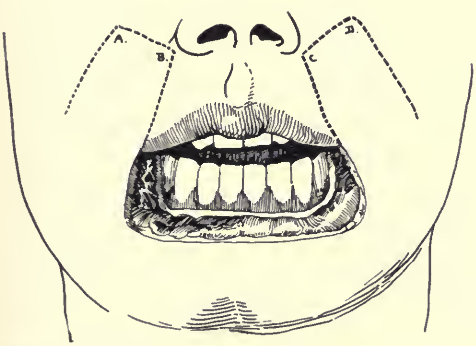

Fig. 156.—Lines of incision for operation of Bruns in repair of lower lip.

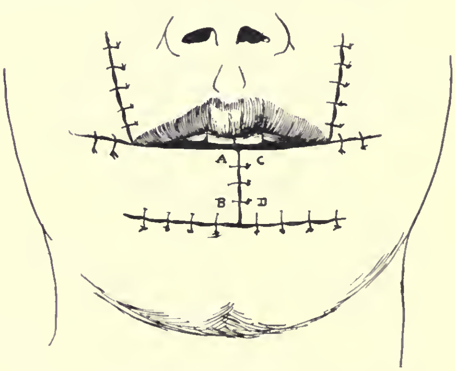

Fig. 157.—Operation of Bruns completed.

excellent. The first incision is just below the jaw from one angle of the lower jaw to the other. The skin and platysma are dissected down and a block dissection is made of the upper neck, including both submaxillary glands. This dissection is made from below upward. Incisions are then made on each side of the cancer at a sufficient distance from the growth and are carried down to the original transverse incision. The lateral flaps are freely dissected from the jaw, keeping close to the skin at the lower part to avoid the lymphatics.

The cancer and the tissues of the block dissection of the neck are removed in one mass. If most of the lower lip is removed with the cancer, the mouth is broadened by a straight incision outward from each angle of the mouth, carried down to, but not through, the mucosa. A triangular incision is then made in the cheek just above the angle of the mouth (Fig. 108). This triangular incision goes down to the mucosa, but does not go through it. The mucosa is cut a half inch above the level of the lower lip and turned down to make a vermilion border. The lateral flaps are brought forward and sutured together in the midline, suturing also the new chin to the soft tissues on the jaw to protect the neck wound from the contents of the mouth.

The lower lip may also be reconstructed by turning down flaps with the

Fig. 158.—Lines of incision for operation of Estlander for repair of lower lip.

Fig. 159.—Operation of Estlander completed.

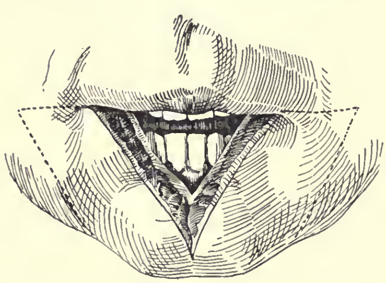

Fig. 160.—Lines of incision for operation of Dieffenbach in repair of lower lip.

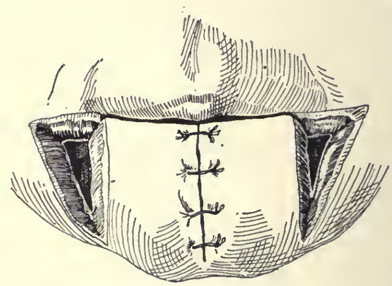

Fig. 161.—Operation of Dieffenbach completed.

base below, the flaps so placed that the incisions to close them will lie in the fold running from the outer portion of the ala of the nose to the corner of the mouth (Figs. 156 and 157).

The operation of Abbe or of Gurdon Buck for reconstruction of the upper lip can be reversed for the lower lip (Figs. 158 and 159). The principle of Dieffenbach which has been referred to in the chapter on plastic surgery can be applied here in securing two flaps, one from each side of the defect, and bringing them together in the midline (Figs. 160 and 161). This leaves a triangular raw surface at the outer portion of each flap, which can be taken up by sliding further flaps, by undermining and suturing, or by grafting skin.

In complete absence of the lip a visor of skin may be turned up from the neck just below the chin and sutured in position (Fig. 162). This, however,

is likely to contract, though this tendency may be lessened by nailing the flap to the jaw with small wire nails or brads and holding it in this position until it becomes firmly fixed. The operations of Sedillot may also be used in some cases (Figs. 163, 164 and 165).

In extensive burns when the mucosa of the lip is not affected but where contraction is marked and scar tissue so abundant that no flap can be secured

Fig. 162.—Lines of incision for "visor" operation in repair of lower lip, according to Viguerte-Morgan.

in the neighborhood, the method of obtaining a flap from the arm offers a solution of the problem. This is the same principle that is known as the Italian method of reconstructing the nose. The flap is best taken with its base near the axilla and the incisions for it are carried around the arm so that the apex of

Fig. 163.—Lines of incision for operation of Sedillot in repair of the lower lip.

the flap lies in front and a little to the outer side of the elbow. Such a flap is well nourished, as it contains vessels that run in the general direction of the blood supply of this part and there is very little twist in the pedicle. If a flap is taken with the apex toward the axilla and base farther down the arm the nutrition is somewhat imperiled and a larger raw surface of the arm is kept in contact with the face than would be with a flap having its base toward the axilla. The mouth is first prepared for the reception of the

flap by thorough excision of its scar tissue and the flap which will furnish ample skin covering is dissected with some underlying fat and sutured in position by interrupted sutures of fine silkworm-gut. The raw surface of the arm is covered with rubber protective, oiled silk, or some of the recent impervious transparent materials that are on the market. The arm is put over

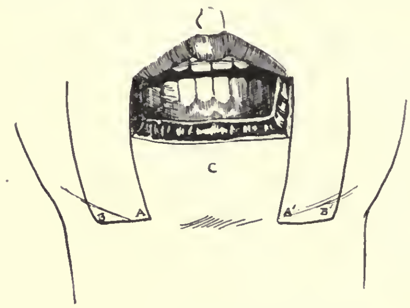

Fig. 164.—Lines of incision for second method of Sedillot in repair of the lower lip.

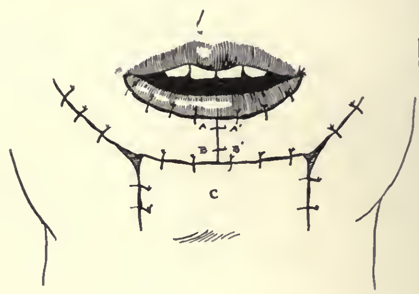

Fig. 165.—Second method of Sedillot completed.

the head after covering it with a flannel bandage and is fastened in position by plaster of Paris bandages which run over the head. The hair is protected by a rubber cap. It is unnecessary, as a rule, to put plaster of Paris around the


Fig. 166.—Method of securing a flap from the arm for repair of lower lip. Photograph taken just before cutting the pedicle of the flap.


Fig. 167.—Ultimate result after repair of lower lip following injury from burn in the patient that is shown in Fig. 166.

neck, which makes dressing the wound difficult (Figs. 166 and 167). At the end of two weeks the pedicle is cut. The flap is undisturbed for about a month after the pedicle is cut and is then refashioned and smoothed to fit accurately

with the adjoining tissues. Particular care is paid to the junction of the flap with the skin of the face in order that there may be no depression along the line of union. The principles for preventing this have been discussed in the chapter on Plastic Surgery.

The nerve supply to these flaps in young patients develops rapidly and within two months from the time the transplant has been made sensation of pain and touch in the transplanted flap becomes perceptible.

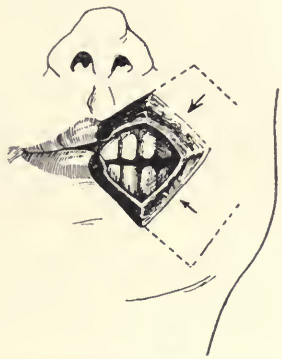

Fig. 168.—Lines of incision for operation of Montet in repair of angle of the mouth.

In a lesion of the angle of the mouth in which both lips are affected the operation of Montet is applicable. He uses two quadrangular flaps, one from the cheek and the other from the chin with the base of each outward. The margins of the flap, which are to form the edge of the lip, are lined with mucosa (Fig. 168). If the corner of the mouth is drawn upward it may be corrected by an operation of the type of Szymonowski, in which a triangular flap is made with the base downward and the apex external to the ala of the nose (Figs.

Fig. 169.—Lines of incision for the operation of Szymonowski for repair of the angle of the mouth.

Fig. 170.—Operation of Szymonowski completed.

169 and 170). This flap is turned into an incision just above the mucous border of the upper lip and so lowers the outer angle of the mouth. The method may also be used when the angle of the mouth is depressed. Here a triangular flap is made which includes the depressed angle of the mouth and this is transferred into a horizontal external cut in the cheek (Figs. 171 and 172).

The vermilion border of the lip can be restored by flaps of mucosa from within the mouth. These are sometimes taken from the inner sides of the upper lip, turned down like a visor after the method of Schulten (Figs. 173,

174 and 175), or if all of the vermilion border has not been destroyed the remaining portion can be dissected free as a flap and stretched to cover the defect (Figs. 176 and 177).

In protrusion of the lower lip, when the mucosa is excessive an oval section may be taken from the mucosa near the point where it is reflected from the inferior maxillary bone and the wound sutured. This will remove the redun-

Fig. 171.—Lines of incision for correction of downward contraction of the angle of the mouth.

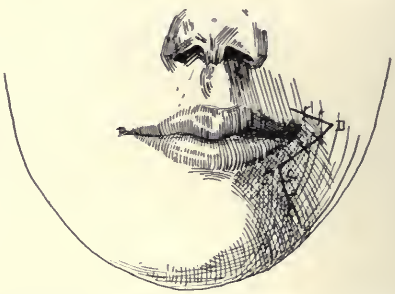

Fig. 172.—Completion of operation for correction of downward displacement of angle of the mouth.

dancy and leave no external scar. Contraction of the mouth is dealt with on the general principles of plastic surgery. Excision of the scar tissue, reserving the mucosa if it is healthy, is an operation that can be done in most instances. The mucosa is used to form a vermilion border for the newly constructed lip (Figs. 178 and 179). In severe burns both lips may be fashioned from the arm, as has already been mentioned.

Defects of the cheek are remedied by flaps from the neighborhood when

Fig. 173.—Lines of incision for operation of Schulten for repair of mucosa of lower lip.

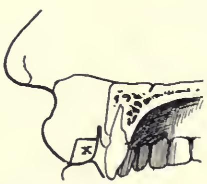

Fig. 174.—Section showing location of flap taken from the upper lip.

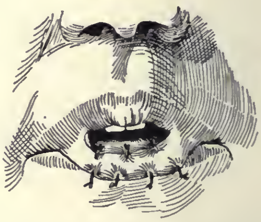

Fig. 175.—The flap, according to Schulten, has been sutured into position. The pedicles are cut ten days or two weeks later.

the defect is not too great. It is necessary to provide an internal lining of either mucosa or skin. If the defect in the cheek also includes a bony defect in the lower jaw a flap may be turned up from the neck containing a section of the clavicle; or a piece of rib may have been previously transplanted beneath the skin of the neck in such a position that it can be included in the flap and turned into the defect. Great care is taken during the dissection to prevent dislodging the attachments of the bone graft or

the section of clavicle. When the clavicle is used it is sawed to the depth of about one-fourth of an inch on each side of the flap before the flap has been completely dissected free, and the bone is severed from the clavicle by a sharp chisel or fine saw. Holes are drilled in the two ends of the bone from the clavicle before it has been severed, protecting the under surface of the clavicle by a retractor slipped behind it to avoid injury to the deeper tissues if the drill should perforate the clavicle (Figs. 180, 181 and 182). It is best to keep the bone

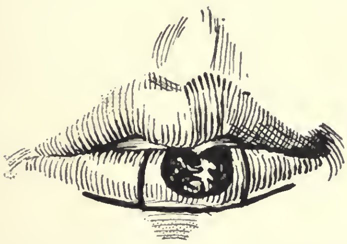

Fig. 176.—Lines of incision for repair of mucosa of lower lip according to the method of Nélaton and Ombredanne.

Fig. 177.—Operation of Nélaton and Ombredanne completed.

firmly fixed to the flap by clamps until it has been secured in the defect. It is fastened to the edges of the defect in the jaw bone with kangaroo tendon passed through drill holes. The skin flap is sufficiently long to turn over and protect the bone from the mouth.

Defects of the cheek that cannot be corrected by sliding flaps from the neighborhood may be repaired by turning flaps up from the neck or by securing flaps from the arm, or from the forehead. If flaps are taken from the neck they will necessarily be long and should be lined by mucosa or else doubled

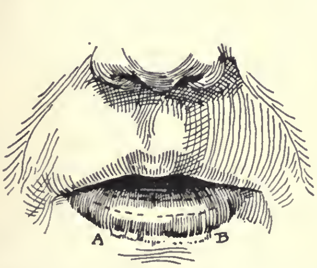

Fig. 178.—Lines of incision for reconstruction of vermilion border of the lower lip. Tissues from "A" to "B" should be excised and the flap indicated by the lines of incision pulled down. This is the operation of Tripier.

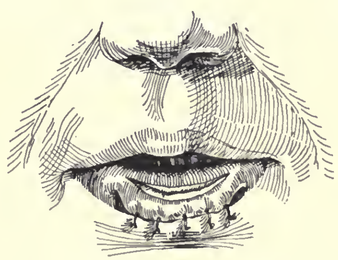

Fig. 179.—The vermilion border of the lower lip reconstructed according to the method of Tripier.

over so as to have an epithelial lining on each side, or if this is impossible a flap may be turned into the mouth with the skin side inward and another flap used to cover the raw surface. If a flap from the neck is used, it being long and in the reversed direction of the blood supply, gangrene may occur. It is best to separate the flap except at its extremities, as has been mentioned in the chapter on Plastic Surgery, "tube" the pedicle, and then gradually divide the end opposite the pedicle. This procedure may take several weeks,

but it will greatly develop the blood supply and will lessen the possibilities of sloughing. The flap can then be doubled on itself before being transplanted, so that it will be abundantly nourished when it is finally fit into the cheek (Figs. 183 and 184).

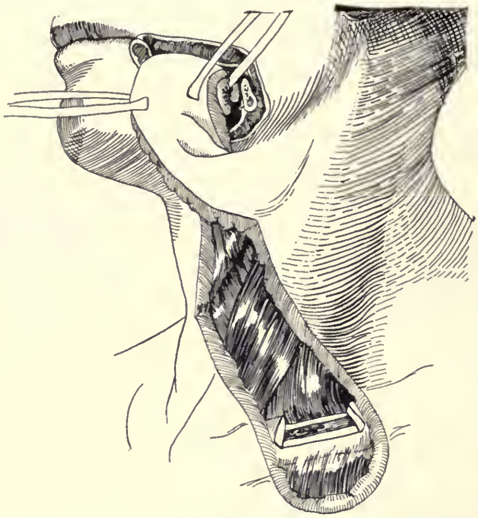

Fig. 180.—Reconstruction of defect in the lower jaw by a pedicle flap including a portion of the clavicle. The flap is long enough to reach over the section of clavicle into the mouth and completely envelopes the bone.

Fig. 181.—Lines of incision for repair of defect in the midline of lower jaw. A piece of rib has been previously grafted under the skin of the flap.

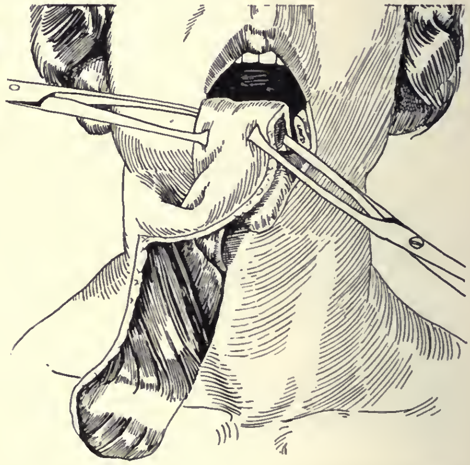

Fig. 182.—The flap with its grafted bone is turned into the defect of the lower jaw. The skin is long enough to fold over the grafted bone.

In defects in the upper part of the cheek in which there is no need for mucous lining, I have turned down a flap from the forehead using the anterior temporal artery as the pedicle. The defect is prepared and a flap of proper size is outlined on the forehead in such a way that it is supplied by the

anterior temporal artery, which is dissected out along with any adjoining veins and some surrounding connective tissue. An incision is made in the skin, merely going through the skin but not deep enough to injure the branches of the facial nerve. The skin is undermined on each side of the incision so the transplanted artery can be covered without tension. The artery is placed in this incision and the flap sutured to the surrounding raw surface. The chief danger in this operation is from too much blood supply. The flap should be punctured at several points so the excessive amount of venous blood can be drained off and it is well not to apply the sutures too closely, in order to afford exit of venous blood between the stitches. If the flap becomes purplish during the first two days a sharp-pointed knife should be inserted between the

Fig. 183.—Lines of incision for repair of defect in the cheek and angle of the mouth. The flap is so fashioned that tip "A" is folded over the rest of the flap and turned into the mouth.

Fig. 184.—The flap indicated in the previous figure has been dissected and placed in the defect.

stitches at several points and the margin of the flap scraped. This procedure together with a few stab wounds may tide over the danger of too much venous congestion, which occurs in the first few days. I was unaware at the time I described this operation that Monks, of Boston, had already employed this principle in reconstructing the eyelid. Blair has suggested a modification for defects lower in the cheek so that the flap could be turned with the skin surface within the mouth and the raw surface externally. Later the raw surface can be covered by Thiersch's grafts or by flaps from the neck. I had previously lined the buccal surface of this flap by a skin flap from the neck, but Blair's suggestion will secure a more stable lining for the mouth, though the raw surface will have no opposing raw surface with which the veins of this flap may become promptly connected to relieve the venous congestion.

A flap from the forehead may be turned down with the pedicle in the temporal region and the pedicle cut after the flap has taken. This is really a much better procedure than transplanting the temporal artery, for the local blood supply of the flap may be developed by compressing the pedicle one or two hours a day after the first week, as described in the chapter on Plastic Surgery, or the pedicle can be severed in successive stages. The great objection to transplantation of the temporal artery alone is that it does not provide a venous return circulation as does a pedicle of skin and subcutaneous tissue.

Willard Bartlett suggests covering the buccal surface of a flap transplanted into the cheek, by turning up a flap of mucosa along with some of the tongue. The tongue is cut loose later. In such an instance it is necessary to remove the teeth or at least to protect the mucosa of the transplanted tongue until its pedicle is cut.

THE EYELIDS

Operations on the eyelids are usually for the purpose of excising neoplasms or for deformity caused by trauma, ulcer, burns or the removal of neoplasms. Occasionally the eyelids turn in, entropion, and the operation for this consists in excision of tissue from the external surface of the upper and lower eyelids. The excision includes not only the skin but the fibers of the orbicularis muscle with some of the thickened tarsal cartilage. The excision is made in such a manner as not to disturb the margins of the lid.

The most common lesion of the eyelid is eversion, or ectropion. If the contraction which caused ectropion were located in one spot or confined to one line, the operation for the correction of this condition would be comparatively simple. Unfortunately, however, the surrounding tissues to a considerable extent are usually affected by the scar tissue and it is often difficult to secure a sufficient amount of normal skin to give satisfactory support to the eyelid.

The types of operations that are applicable may be divided into, (1) skin grafting, with free grafts, (2) sliding flaps or pedunculated flaps from the adjacent tissue, and (3) pedunculated flaps from a distant part. These types of operations are suitable for either ectropion or reconstruction of the lids. The only difference is that in reconstruction of the lids, where the conjunctiva and the tarsal cartilages are absent, it is essential to have the inner raw surface of the graft covered with epithelium. To accomplish this a Thiersch graft is placed on the flap before it is shaped into an eyelid.

Skin grafting for eversion of the upper or lower lids is not satisfactory as a rule unless whole skin grafts are used. If the eversion is due to contraction of a scar, and the scar is excised and a Thiersch graft applied, a recurrence of the contraction may be looked for unless the scar is very superficial. In order, then, to correct contraction in a deep injury of the eyelid it is necessary to transplant whole skin. When the operation is for ectropion where the tarsal cartilage and the conjunctiva are well preserved the whole skin graft usually gives excellent results. It was for this type of

Fig. 185.—Line of incision for releasing contraction of the upper lid according to operation of Gillies.

Fig. 186.—Dissection of contraction of upper lid.

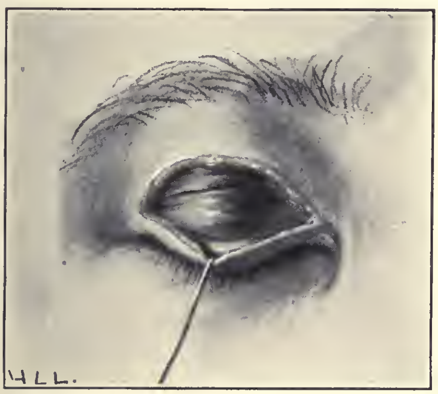

Fig. 187.—The upper lid is freed and turned down.

Fig. 188.—Thiersch graft is placed on a mold of wax. (Gillies.)

Fig. 189.—The mold, with the Thiersch graft placed with the epithelium next to the mold, is sutured into the raw surface left by dissecting the contractions of the upper lid. (Gillies.)

Fig. 190.—The sutures which catch the skin of the lids and the graft are tied. The sutures and mold are removed in about ten days. (Gillies.)

operation that the whole skin graft of Wolfe was originally devised. If there is considerable infection about the eye, which cannot be cleared up, the graft may not be successful. The technic of its application is the

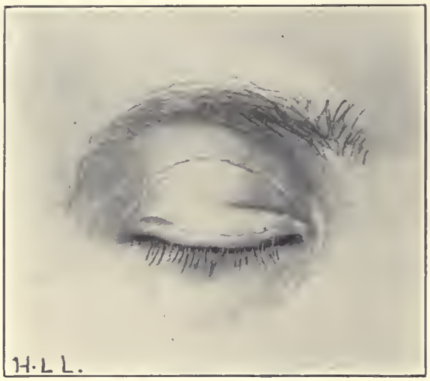

Fig. 191.—The late result of operation of Gillies for eversion of upper lid.

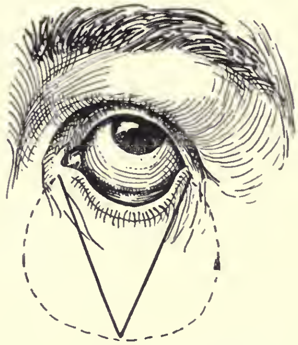

Fig. 192.—Lines of incision for the Wharton Jones operation for ectropion of the lower lid.

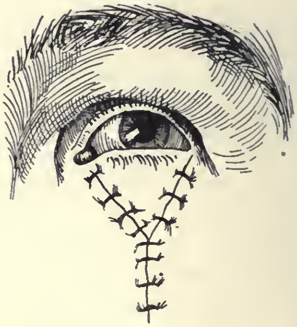

Fig. 193.—The operation of Wharton Jones completed.

Fig. 194.—Lines of incision for operation of Dieffenbach for ectropion of lower lid.

Fig. 195.—Operation of Dieffenbach completed.

same as has been described in the chapter on Plastic Surgery. In order to prevent infection from the secretions of the eye, it is necessary to keep the graft covered with moist saline gauze, which should be changed several times a day.

Gillies[1] finds that when the scar contraction of a lid is very superficial and all of the corium has not been destroyed, the use of Thiersch grafts may be successful. The eyelid is mobilized and the scar dissected away (Figs. 185, 186, and 187), then the graft is applied to a mold of dental wax made to

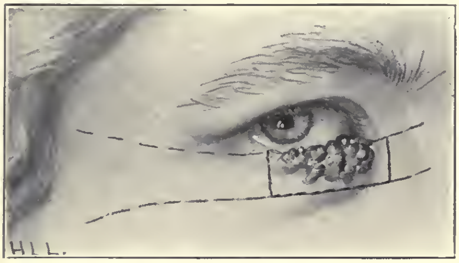

Fig. 196.—Lines of incision for operation of Knapp for repair of lower lid.

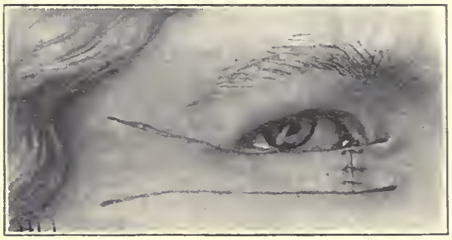

Fig. 197.—Operation of Knapp completed.

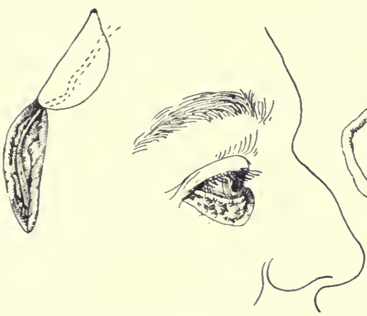

Fig. 198.—Operation of Monks for repair of lower lid. A flap is dissected from the forehead with the temporal artery as pedicle.

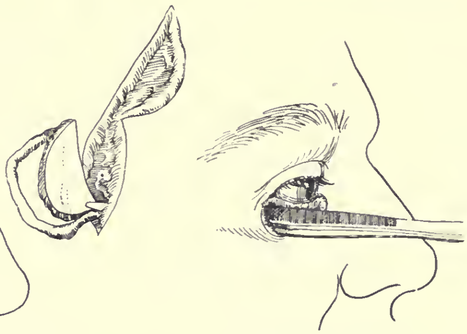

Fig. 199.—The flap is freed and caught with forceps, to be drawn through a tunnel from the lower lid to the temporal artery.

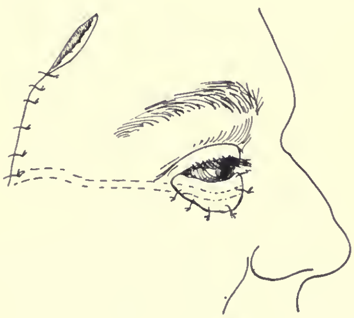

Fig. 200.—The operation of Monks completed.

fit the defect, with the raw surface of the graft external (Fig. 188). The mold covered with the graft is fastened in the defect with sutures which catch the margins of the graft (Figs. 189 and 190). The sutures and the mold are removed in a week or ten days (Fig. 191).

[1]Surg., Gynec. & Obst., February, 1920, p. 133.

In all operations upon the eyelid the lids are sewed together after trimming the eyelashes, or a better plan still is to overcorrect the lids by overlapping them. If, for instance, the lower lid is to be operated upon, it may be folded over the upper and the sutures in its edge are fastened to the forehead by adhesive plaster. This method has been made use of by a number of surgeons to obtain overcorrection while the lid is healing. It is highly essential to overcorrect the lid in any plastic operation, because there is a tendency to contraction.

If the whole skin graft cannot be used satisfactorily, the method of sliding flaps from the neighborhood must be considered. The operation to be selected depends to a large extent upon the character of the contraction. If the contraction is linear or very limited the operation of Wharton Jones is excellent. Here a V-shaped incision is made, beginning at each extremity of the lower eyelid and uniting at an acute angle some distance below the lid. If the contracting band is in the midline or near a line of the incision it is thoroughly excised. The skin is well undermined along the margins of the incision and the wound is sutured, converting the V-shaped incision into a Y and so pushing up the lower lid (Figs. 192 and 193). The method of Dieffenbach can also be used. This consists in taking a quadrangular flap whose upper end is about on the level of the normal upper border of the lower lid when the eye is closed, but external to the outer canthus of the eye. The base is below and inward. After excising the scar tissue or the growth below the eyelid, this flap is slid inward to replace the excised area and the triangular denuded area left by the graft is partly sutured and partly covered by a Thiersch graft (Figs. 194 and 195). A flap can also be taken with its base near the outer canthus and extending either downward or upward, or with its base near the inner canthus and extending downward. This flap may be turned into the raw surface left by excision of the scar tissue of the lower lid. The general principles of plastic operations as described under Plastic Surgery are followed here. A quadrangular flap may be slid according to the method of Knapp on a horizontal plane with the defect caused by excising the scar tissue of the lower lid (Figs. 196 and 197). If the deformity is confined to the lower lid and there is a redundancy of tissue in the upper lid a flap of skin may be turned down, visor-like, from the upper lid to the lower lid. Here a strip of skin is cut from the upper lid by two parallel incisions, which form a bridge of tissue attached at its two ends, one above the outer and one above the inner canthus of the eye. This bridge is turned down according to the method of Landolt to the lower lid and sutured in position.

The method of Monks consists in outlining the eyelid on the forehead and dissecting out a pedicle containing the anterior branch of the temporal artery and vein with some surrounding connective tissue. This flap is carried under a tunnel burrowed from the lower end of the incision, so the anterior temporal artery nourishes the reconstructed lower lid (Figs. 198, 199 and 200). As described on p. 209 I used the same principle in supplying a flap from the forehead for defects of the cheek. At the time I reported this I was unaware

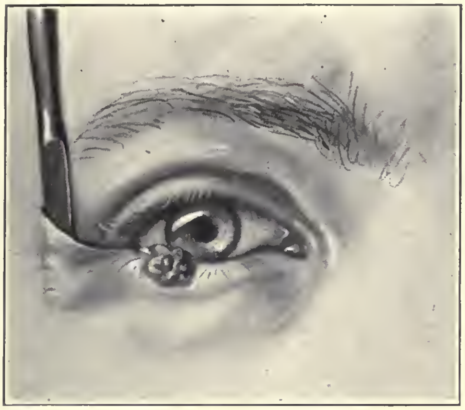

Fig. 201.—Operation of Gibson for repair of lower lid. A pocket is made for the reception of Thiersch graft.

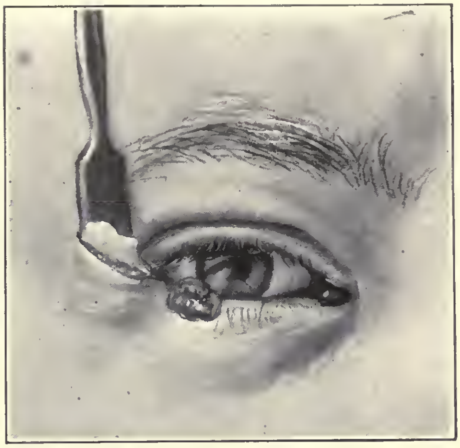

Fig. 202.—Thiersch graft is placed in position.

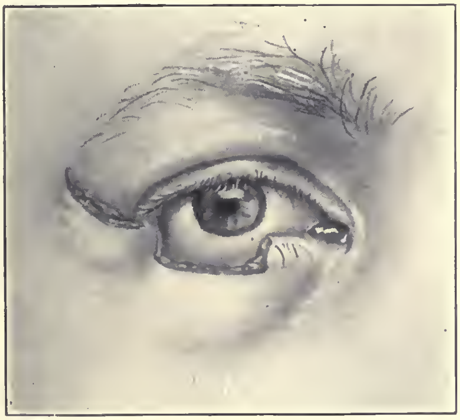

Fig. 203.—The growth on the lower lid is excised.

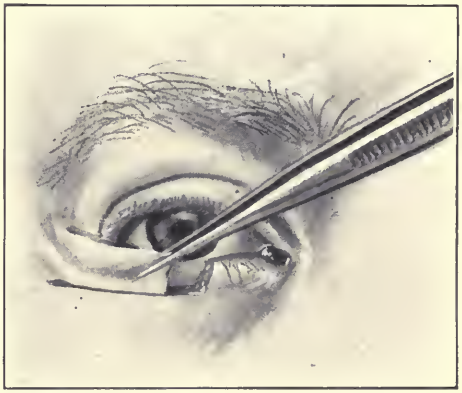

Fig. 204.—Ten days after the grafting the flap is dissected according to the method of Gibson and drawn over the defect in the lower lid.

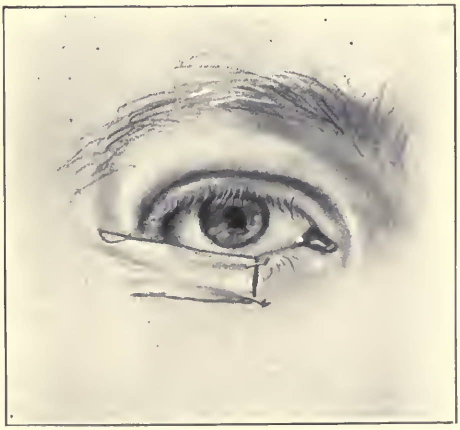

Fig. 205.—The operation of Gibson completed.

Fig. 206.—Lines of incision for operation of Syndacker-Morax for repair of both lids.

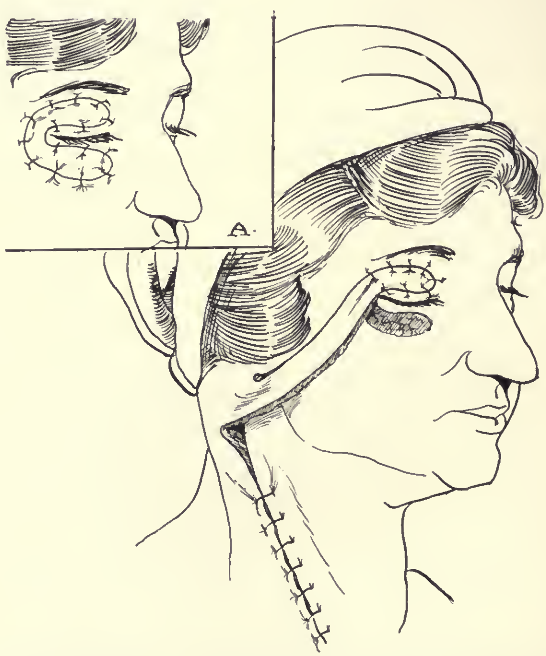

Fig. 207.—The pedicle has been sutured into position to the upper lid. Ten days later (A) the pedicle is cut and the lower portion of the flap turned into the defect of the lower lid.

of the operation of Monks and unconsciously used the principle that he had established several years previously. On account of defective venous circulation I have found this principle unsatisfactory in larger flaps.

Gibson uses a quadrilateral flap which is best explained by the accompanying

Fig. 208.—Deformity following a burn in a boy, J. M. Note marked eversion of both lids, particularly on the right side.

Fig. 209.—The patient shown in Fig. 208. The mouth has been repaired by pedicled flap from his arm. Both lids of the right eye have been freed, sutured together, and covered wi'h a pedicled flap from the forearm, which was left in position about two weeks before the pedicle was cut.

Fig. 210.—Patient shown in Fig. 209. The flap which covered both lids of the right eye has been split. The patient is shown with his eyes closed as tightly as possible to demonstrate lack of eversion.

illustration (Fig. 201). A horizontal incision is made from the outer canthus of the eye and a Thiersch graft tucked in (Fig. 202). This tissue is shaped into a quadrangular flap after the graft has taken and is slid inward to supply the defect

in the lower lid (Figs. 203, 204 and 205). Only the outer half of the lower lid can be reconstructed by this method. For the inner side of the lid a flap may be taken from the bridge of the nose and turned down.

It must constantly be borne in mind that if the operation is for reconstruction of the lower lid, and not for correcting eversion, whole skin grafts cannot be used, for it is necessary to cover the raw surface next the eye with a Thiersch graft. This should be done on a flap two weeks before the flap is

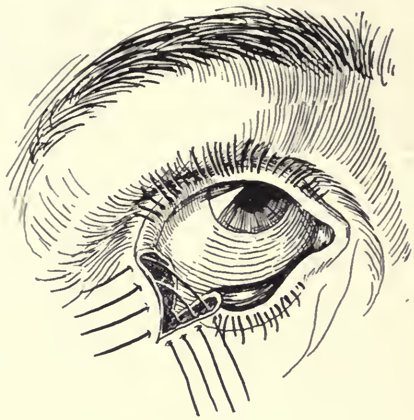

Fig. 211.—Excision of V-shaped section of lower lid for senile ectropion. Operation of von Ammon.

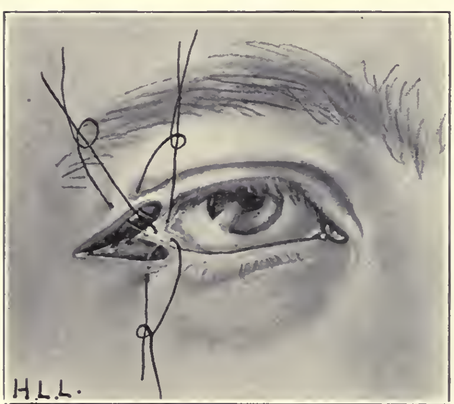

Fig. 212.—Lengthening the outer canthus of the eye according to von Ammon-Agnew.

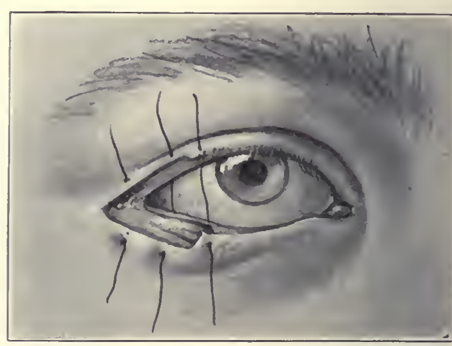

Fig. 213.—Narrowing the outer canthus of the eye according to Walthers.

turned into its position. On account of the secretions of the eye it is difficult or impossible to graft the flap after it is in permanent position and if it is not thus covered contraction of the raw surface will interfere with the success of the operation.

Flaps from a distance are obtained from the neck or from the arm. If from the neck, a long narrow flap is cut according to the method of Syndacker-Morax, with the base about the mastoid region and the tip of the flap over the

sternoclavicular articulation (Figs. 206 and 207). As such a flap is long and narrow it would be safer to utilize the principle mentioned in the chapter on Plastic Surgery and first make a bridge of the tissue for the flap, "tube" the pedicle, and gradually cut the distal end so as firmly to establish the circulation.

A pedicle flap from the arm may be obtained for the eyelids. It should be from the inner surface of the arm or from the inner surface of the forearm. Skin from these regions matches well with the eyelids and should be used when the whole skin graft is indicated. A pedicle flap from this region is taken with a broad base and with a flap large enough to have an abundance of tissue. The eyelids are denuded by dissecting away the connective tissue thoroughly and sewing the lids together. If only the lower lid is everted a flap is sewed in this position, but if both lids are affected a large flap is made to cover

Fig. 214.—Reconstruction of the eyebrow by turning down a flap from the forehead.

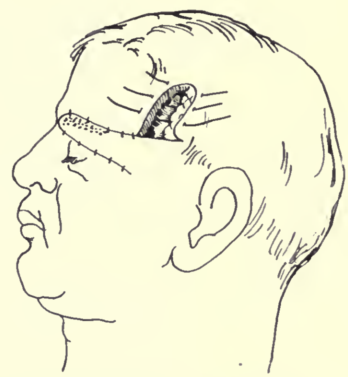

Fig. 215.—Reconstruction of the eyebrow by turning down a flap from the temporal region.

both lids (Figs. 208, 209 and 210). The pedicle is severed in about two weeks, after compression for an hour at a time for five days, and a week later the flap is split to make both upper and lower lids. The accompanying photograph shows this method after the pedicle has been cut and before the flap has been split to form the eyelids.

In eversion of the eyelids which has existed for a long time, either as a result of cicatricial contraction or because of a paresis of the tissues as in senile ectropion, a V-shaped section of the lid should be removed. This includes the conjunctiva and the tarsal cartilage, as well as the skin. The wound is sutured carefully with fine sutures of arterial silk, bringing the tissues into accurate approximation (Fig. 211). At the margin of the lid where there is the greatest strain it is wise to insert a somewhat stouter silk suture. This may be all that is necessary for atonic ectropion, but in ectropion from scar tissue contraction, it is only one step of the operation and should be followed by either a whole skin graft or a flap operation.

Deformities that involve shortening or lengthening the palpebral opening can easily be corrected along the principles of plastic surgery. If the opening

is to be lengthened, the outer canthus is split or a triangular area excised and the conjunctiva is sutured to the skin (Fig. 212). In shortening the palpebral tissue, a triangular area including the outer canthus, is denuded and sutured as a straight line (Fig. 213).

In reconstruction of the eyebrows whole skin grafts may be used, taking the skin from some hairy region of the body as the pubes and transplanting

Fig. 216.—Painful and contracted scar left after removal of an eye. (J. S. Davis.)

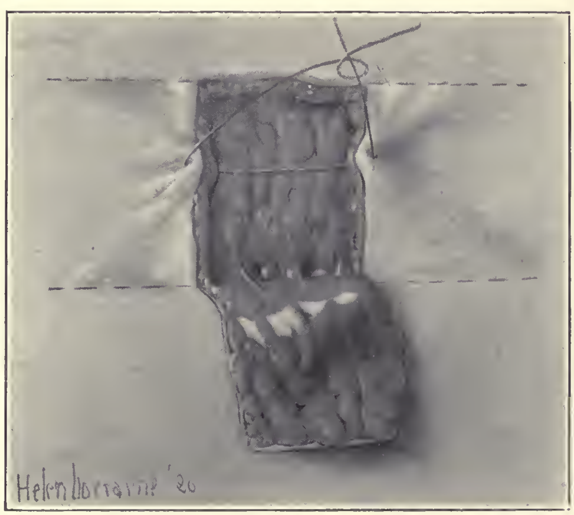

Fig. 217.—A flap dissected from the abdomen according to the method of J. S. Davis.

it according to the technic of whole skin grafting, which has been described. A pedicle flap can be used by turning down a flap from the scalp (Fig. 214) with its base in the temporal region (Fig. 215), or, if the defect only involves one eyebrow and the other eyebrow is well developed, this eyebrow can be split to form a flap with its base on the bridge of the nose and the flap containing half

an eyebrow turned over to the region of the defect. A hairy flap should be shaved before it is transplanted.

After extensive operations for cancer of the lids, involving the eyeball, it is sometimes difficult to close the socket of the orbital cavity. The bone furnishes scant nutrition for the scar and frequently the contraction and

Fig. 218.—The abdominal flap has been sewed to the incision in the hand, and two weeks later the pedicle of the flap is cut and the hand transferred to the region of the eye. (Davis.)

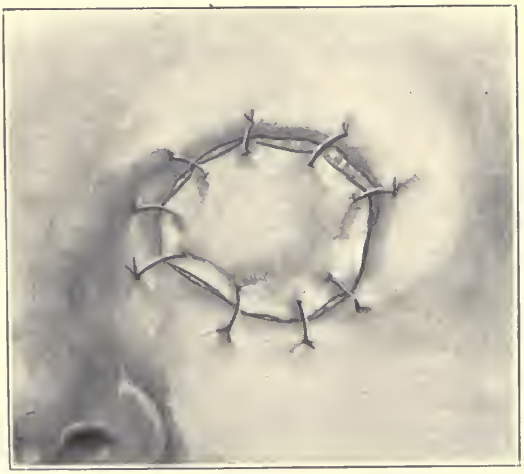

Fig. 219.—The painful scar in the eye socket has been removed and the flap on the hand sutured in position. Ten days later its connection with the hand is divided. (J. S. Davis.)

pulling on the surrounding tissue cause great deformity and pain (Fig. 216). After denuding the cavity a flap from the forehead may be turned into this defect, or the operation of J. S. Davis may be done. A flap of skin with a thick pad of fat from the abdomen (Fig. 217) is sutured into an incision in the palm of the hand. After about twelve days the attachment of this flap to the abdomen is severed and the hand containing the flap (Fig. 218) is transferred to the region of the eye where the flap is sutured in position. When its nutrition has been established in its new location its connection with the palm of the hand is severed (Fig. 219).

EARS

Deformities of the ear which consist of congenital enlargement or malposition of the ear are comparatively easily corrected, but the construction of an ear when it is congenitally absent or when it has been removed by trauma is a very difficult and unsatisfactory procedure. Ears that stand out from

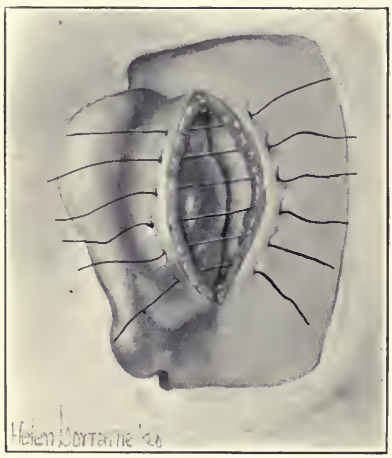

Fig. 220.—The operation of Monks for prominent ears.

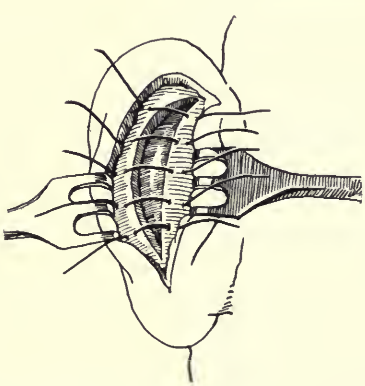

Fig. 221.—Operation of Luckett for prominent ears.

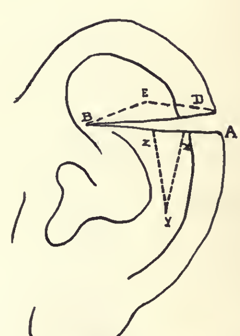

Fig. 222.—Method of reconstructing ears that are too large.

the head in unusual prominance are reduced by the operation of Monks, in which an ellipse of skin and subcutaneous tissue is removed from the back of the ear, and the skin edges of the wound are sutured together (Fig. 220). If

Fig. 223.—Lines of incision for the operation of Szymonowski for reconstruction of the ear.

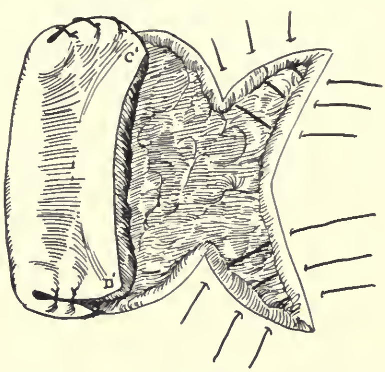

Fig. 224.—The flap is dissected up and folded on itself.

Fig. 225.—Lines of incision at "A" and "B" show outlines of flap.

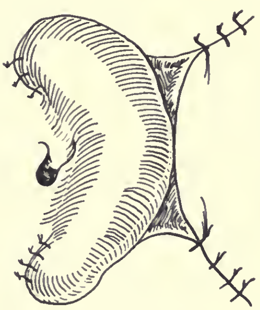

Fig. 226.—Flaps "A" and "B" are raised and the extremities of the new ear are brought forward.

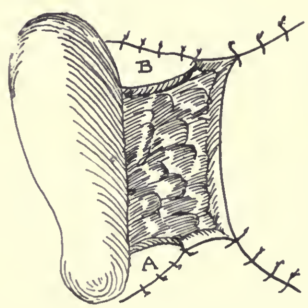

Fig. 227.—The flaps "A" and "B" are transferred posteriorly.

the deformity is more extensive and the ears are large the operation of Luckett is more satisfactory. Here incisions are made in the posterior surface of the ear to remove a crescentic area of skin, and also a similar area of cartilage after undercutting the skin. Care is taken not to carry the incision through the

ear, so there will be no scar visible on the anterior surface of the ear. The cartilage is sutured with interrupted sutures of catgut inserted somewhat like the Lembert intestinal sutures, turning the edges of the cartilage forward to form a ridge, which is usually absent in these large ears (Fig. 221). When the ear is unduly large it can be reduced by excision of a triangular area, which may be accompanied by excision of smaller triangles in order to reduce the size of the ear not only from above downward but from before backward (Fig. 222). The size of the lobule of the ear can be lessened by excision of a triangular area.

Fig. 228.—Lines of incision for operation of Roberts for reconstructing the ear.

Fig. 229.—The flap is dissected up and folded upon itself. Lines of incision for construction of lobe of the ear are shown.

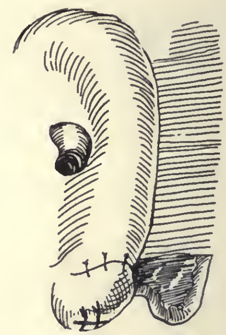

Fig. 230.—The lobe for the ear is dissected up and attached to the body of the ear.

Complete reconstruction of an ear is difficult and unsatisfactory. The operation of Szymanowski has had considerable vogue. The incisions are made according to the illustration (Figs. 223, 224, 225, 226 and 227). If the hair is too abundant in this region the operation of Roberts may be used (Figs. 228, 229 and 230). Here a flap is raised, as shown in the illustrations, and the posterior part is folded back to give thickness and a rim for the ear. After this has taken, an independent flap is formed lower down to construct the lobule and is connected with the original flap.

THE EXTERNAL NOSE

Operations on the nose, like the surgery of other prominent portions of the face, consist largely of plastic operations, intended to correct defects, either congenital or resulting from disease or trauma. An occasional type of deformity is that which unfortunately follows the use of a paste in removal of malignant growths from the nose. These cancers can be removed much better and with less pain and resulting deformity by the electric cautery, but the superstitious dread of an operation will often cause a patient to suffer great agony and the conspicuous deformity which results from the paste rather than have the simpler, more effective, and less deforming operation.

Occasionally there is a marked hypertrophy of the skin of the nose resulting from acne. This hypertrophy, which is termed rhinophyma, is best removed by excision of the skin down to the cartilage. The finger is placed in the nostril to prevent injury to the cartilage and a clean excision is done. It is best to split the growth in the middle and remove it in two halves so that the outline of the cartilage can be readily distinguished, each half being dissected from the middle line. The raw surface is then grafted.

In repair of small or partial defects of the ala of the nose, without extensive scar tissue in the neighborhood, flaps can be taken from the skin in the region of the ala. If the defect consists of partial destruction of the ala with the edge of the ala drawn high up, it is best to take a flap from the margin of the defect after making an incision to lower the ala. This

Fig. 231. Fig. 232. Fig. 233.

Fig. 231.—Lines of incision for operation of Esmarch for reconstruction of ala of nose.
Fig. 232.—The pedicled flap is turned into position. Ten days later the pedicle is severed.
Fig. 233.—Operation of Esmarch completed.

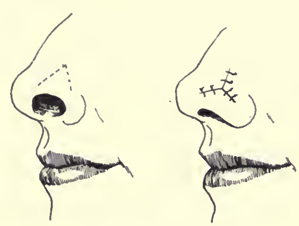

Fig. 234. Fig. 235.

Fig. 234.—Lines of incision for operation of Dieffenbach for defect of ala of nose.
Fig. 235.—Operation of Dieffenbach completed.

can be done by the operation of Esmarch, in which a flap is taken from the nasolabial fold and turned up into either the defective ala (Figs. 231, 232 and 233), or better still into the incision by which the ala has been shoved down. This usually leaves but little scar because the raw surface from which the flap is taken can be sutured to correspond with the nasolabial fold. The principle of the Wharton Jones operation on the eye can sometimes be employed, making a V-shaped incision, shoving down the edge of the ala and suturing the resulting wound as a Y (Figs. 234 and 235). Sometimes a flap of mucosa can be taken from the septum of the nose with its base at the tip of the nose.

If considerable cartilage is destroyed, or if a large hole is left it will be

necessary to line the nasal surface of the flap with epithelium. This can sometimes be done by a flap of mucosa from the septum of the nose. I have done this with considerable satisfaction in a case in which there was a defect in the ala following the application of a paste. The procedure is shown in the accompanying illustrations (Figs. 236, 237, 238, 239, 240, and 241). This flap is turned into the defect and the pedicle is subsequently cut. This mucosa often matches the skin very well. If the defect is large and there is

Fig. 236.—Photograph showing defect in the nose caused by application of paste.

Fig. 237.

Fig. 238.

Fig. 239.

Fig. 240.

Fig. 237.—Lines of incision for correcting defect shown in Fig. 235.
Fig. 238.—The small bridge of tissue is cut away.
Fig. 239.—A flap is formed, constituting the lower border of the ala.
Fig. 240.—A flap from the mucosa of the septum as indicated in Fig. 238 is turned into the wound.

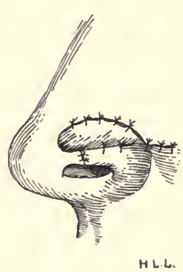

Fig. 241.—The pedicle to this flap is severed and the flap sutured into position.

much surrounding scar tissue the skin flap is first raised and then covered with a Thiersch graft, or a flap from the skin along the margin of the defect is turned into the wound so that it hinges on one margin of the defect and is sutured with its raw surface outward to the other margin of the defect which has been previously freshened by cutting off a small ribbon of tissue with a sharp-pointed knife. Another flap is turned up from the nasolabial fold to cover the raw surface of the first flap. Sometimes with extensive scaring and sinking of this portion of the nose it is best to remove the scar tissue and skin

from the sunken portion of the nose that lies between the tip of the nose and the nasal bone, and transfer a flap from the forehead.

As operations for defects resulting from cancer are usually done in elderly people, great care must be exercised in making a flap with a long narrow pedicle. In securing a flap from the forehead the flap should first be outlined with its base near the bridge of the nose to include an angular artery. This flap extends obliquely across the forehead and that portion which is to be used for reconstructive purposes should be as near the hair line as possible so that any undue scar on the forehead can be covered by arrangement of the hair. This

Fig. 242.—A flap from the forehead has been turned into a defect in the tip of the nose, which also resulted from the application of paste. The tip of this flap is being gradually severed. Note the incision on a level with the eye, through two-thirds of flap.

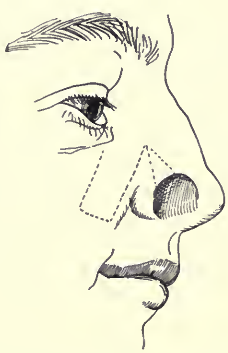

Fig. 243.—Lines of incision for operation of Nélaton for correction of defect of the ala.

Fig. 244.—The operation of Nélaton completed.

flap is dissected free except at its two extremities and the principle of gradual incision that has been already discussed (p. 178) is utilized. The part of the flap that is to be severed is cut by short incisions beginning about the fourth day after the operation (Fig. 242), or else it is clamped for an hour at a time with soft clamps that will not injure the tissues, beginning about the fourth day after operation. In this way the blood supply is developed from the pedicle of the flap and its distal attachment can be completely severed in about twelve days. It is turned down with some periosteum and, if desired, small chips of attached bone,

which are removed from the skull with a chisel. It is sutured into the defect and after ten days or two weeks the pedicle is severed, cutting a third every two days, and returned to fill up as much of the defect in the forehead as possible.

A flap to correct a defect in the ala can sometimes be taken with its base near the angle of the eye so that the incised wound will lie in the fold between the nose and the cheek (Figs. 243 and 244). The columna of the nose can be restored by taking a flap of skin from the tip of the nose and turning it down, or by the method of Lexer, who obtains a flap from the mucosa of the upper

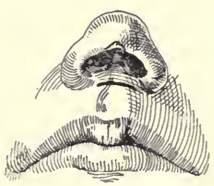

Fig. 245.

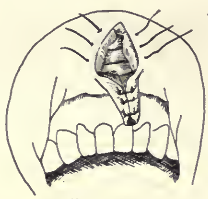

Fig. 246.

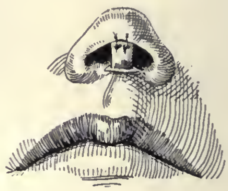

Fig. 247.

Fig. 245.—Lines of incision for the operation of Lexer for the restoration of the columna.
Fig. 246.—A flap is taken from the mucous surface of the under lip, with the base toward the nose.
Fig. 247.—The operation of Lexer completed. The flap is brought through the transverse incision in the lip and is attached by two sutures to the nose.

Fig. 248. Fig. 249.

Fig. 248.—Lines of incision for operation of J. S. Davis for restoration of the columna.
Fig. 249.—The flaps outlined in the previous figure are turned into position.

lip with its base at what would be the normal base of the columna. The lip is perforated at this point and the flap drawn through and sutured to the tip of the nose (Figs. 245, 246 and 247).

The operation of J. S. Davis for restoring the columna consists in taking two quadrangular flaps from the upper portion of the upper lip with their pedicles close to the midline near the anterior margin of the floor of the nose and with the free ends beyond the alae. The flaps are turned inward with the raw surfaces approximated to each other and the tips of the double flap attached

to the tip of the nose (Figs. 248 and 249). This operation is only suited for individuals who have a very long upper lip.

Reconstruction of the nose in which all, or a major portion of the nose has been destroyed is an operation that requires skill and patience. Too frequently the illustrations, in order to show the steps of the operation, give the impression that it is comparatively easy and that the desired results can be obtained with one or two operations. This is far from true and unless any plastic operation upon the nose is well planned, skilfully executed, and followed by a number of minor operations for corrective purposes, the results will be unsatisfactory to the patient and somewhat humiliating to the surgeon. This is particularly true when operations are undertaken for reconstruction of practically the whole nose. Such plastic work necessarily is done by flaps, and flaps from the cheek while furnishing abundant material for partial defects are insufficient for all

Fig. 250.—Lines of incision for the operation of Langenbeck for reconstruction of the nose.

of such an extensive repair. The two practical methods are by securing a flap from the forehead, called the Indian method, or obtaining a flap from some distant part, as the arm or neck, called the Italian method. Wherever the flap is obtained it should be carefully outlined, preferably with a pattern that can be cut from rubber dam, which is easily sterilized. The flap should be at least a third larger than appears necessary in order to allow for shrinkage.

The *Indian method*, taking flaps from the forehead, has numerous modifications. The principle, however, is illustrated in operations such as those of Langenbeck (Fig. 250) or Labat-Blasius (Figs. 251 and 252). In these operations the base of the flap is so placed that it will secure the nutrition of the angular artery from the inner corner of the eyebrow and the flap is carried either straight up or to one side, depending somewhat upon the length of the nose and the character of the forehead. The flap should be so placed that the twisting to bring it in position will not be too great. It is best to outline a

columna in the flap. If the patient is old and there is reason to suspect insufficient nutrition the flap can be first outlined and dissected free except at its pedicle and at its tip. Rubber tissue is carried beneath the flap, and the distal portion is gradually severed to develop a blood supply at the base, a principle that has already been emphasized. Some operators, as Langenbeck or

Fig. 251.—Lines of incision for the operation of Labat-Blasius for reconstruction of the nose.

Fig. 252.—Flaps outlined in the preceding illustration have been dissected and sutured to construct the alæ of the nose.

Labat-Blasius, prefer to construct the columna and the alæ of the nose at the extremity of the flap about ten days or two weeks before turning down the flap so that the nostril has a lining of the tucked edges of the flap.

If the bony framework of the nose has been destroyed it will be necessary to provide some cartilagenous or bony support. This is done preferably before the flap is turned down though it can be done after the soft tissues have been

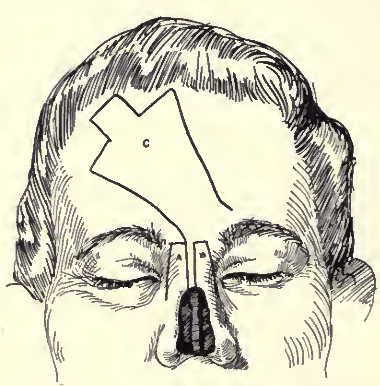

Fig. 253.—Lines of incision for operation of Keegan for reconstruction of the nose.

placed. If it is done beforehand, a thin section of the skull may be chiseled up along with the flap. This is difficult of execution and it is even more difficult to prevent displacement of the bone from the flap. Such a flap, too, must be invariably turned onto the raw surface of another flap having its epithelial surface internal and lining the cavity of the nose.

It is an essential principle in any complete reconstruction operation on the

nose that the flap with which the nose is made must have an epithelial lining on its internal surface. The older operations which did not provide for this were seldom satisfactory. Great improvement has been made in reconstruction of the nose by first lining the flaps with epithelium by Thiersch grafts, before they are put in position, or by turning in a pedicle flap from the cheek, and by forming a supporting frame work preferably by the insertion of strips of cartilage. If there is a small amount of tissue left at the bridge of the nose two flaps can be turned down according to the method of Keegan (Fig. 253) with their bases at the upper margin of the defect of the nose, or we may use the method of Thiersch, in which preliminary flaps are turned in from the cheek with the base of each flap hinging on the lateral margins of the defect (Fig. 254). This can be done at the same time that the frontal flap is turned in position so that both raw surfaces can be approximated, which will prevent infection and at the same time will be mutually helpful to both flaps in the

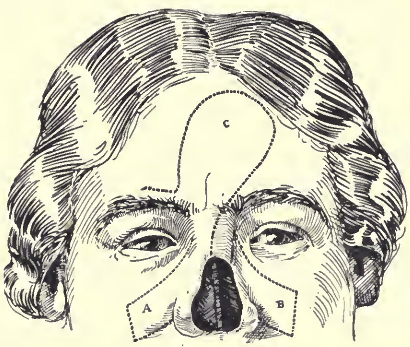

Fig. 254.—Lines of incision for operation of Thiersch for reconstruction of the nose.

blood supply. After turning the flaps in position they are sutured with interrupted fine silkworm-gut, horsehair, or silk. The pedicle of the frontal flap is cut in from ten to fourteen days. Reconstructive operations under local anesthesia should be done at intervals of a few weeks until a satisfactory result is obtained.

The *Italian method* of obtaining flaps from the arm or neck has the advantage of not leaving a conspicuous scar on the forehead, but the disadvantage of causing considerable discomfort to the patient who is forced to keep the arm to the head for several days. These flaps are outlined on the arm with the base near the elbow. The arm is first placed on the head and the flap is marked out in such a manner that the arm can be held in as comfortable a position as possible after the flap has been applied to the nose. If the bony frame-work of the nose is lacking it is best to transplant cartilage under the flap and dissect the flap partly free three or four weeks before the flap is applied to the nose. The flap can be taken from the forearm. Israel recommends a flap from the forearm with the pedicle up and the tip near the lower end of the ulna (Fig. 255). He removes the subjacent portion of the ulna bone, taking a strip of the ulna one-third of an inch wide by about two and one-half

inches long. This is removed with a fine saw in order not to fracture the ulna. The skin flap with the ulna attached is first outlined and the bone is separated except at its upper end which is left attached for about nine days. The nose is modeled as well as possible on the forearm and about twelve days after the graft from the ulna has been separated the flap is sutured to the nose, the arm being held in position for two weeks (Fig. 256).

The flaps from the arm for complete reconstruction of the nose, like those from the forehead, should contain cartilage, if bone is not provided for as in the method of Israel. The cartilage is inserted between the skin and the deeper layers of fat and is permitted to stay in this position for at least two or three weeks before attempting to outline the flap or suture it to the nose. Cartilage appears to be much better than bone, as it can be molded satisfactorily and unlike bone does not tend to atrophy and absorb. Cartilage is obtained from the costal cartilages.

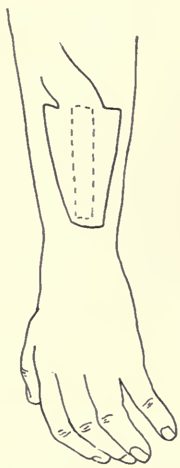

Fig. 255.—Lines of incision for operation of Israel for reconstruction of the nose by a flap from the forearm.

Fig. 256.—The flap from the forearm has been dissected free and is sutured into position on the face.

Mandry has suggested a flap from the neck which includes a portion of the clavicle.

A few operations have been done in which the finger has been used as a substitute for the nose. Davis[2] says: "I have noted that a surgeon seldom reports more than one case operated upon by this method. This may be due to the fact that only one patient requiring this kind of operation has come under his care, but my feeling is that it is unnecessary to lose a finger when better results can be obtained by other methods." If this operation is done the technic of Baldwin appears to give the best results. Baldwin uses the ring finger of the left hand, which is split in the midline on the palmar surface, and transverse incisions are made at the level of the nail and at the base of the finger (Fig. 257). The tip of the finger including the nail and its matrix is removed

[2] Plastic Surgery, by Davis, J. S. Philadelphia, P. Blakiston's Son & Co., p. 467.

and the finger transplanted to the defect in the nose, which has previously been prepared so that the raw surface of the distal phalanx of the bone is imbedded into a pit gouged out of the frontal bone at the upper part of the bridge of the nose.

A reconstructed nose must have a number of minor plastic operations in order to secure satisfactory results. These operations are also some-

Fig. 257.—Dissection of a flap from the finger as the first stage in the operation of Baldwin for reconstruction of the nose from a finger.

times done on noses that are congenitally misshaped. The size of the nose may be reduced by the method of Joseph in which a long narrow triangular flap of tissue is taken from the anterior border of the nose with the apex at the bridge of the nose. At the base of this triangle on the tip of the nose a small

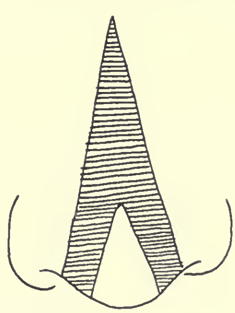

Fig. 258.—Lines of incision for the operation of Joseph for reconstruction of the nose.

triangle of tissue at the bottom of the larger triangle is left (Fig. 258). If the bone is too large it can be resected with a fine saw or chisel but care should be taken to preserve the excised cartilage and to avoid opening the nasal

mucosa if possible. When a sufficient amount of bony and cartilagenous tissue has been removed, strips of the preserved cartilage are replaced on the nasal mucosa in a manner to give a symmetrical outline when the skin is sutured.

If one ala is too low it may be corrected by the method of Joseph (Figs. 259 and 260) or by making a straight incision on the anterior border of the nose from the bridge to the tip and then taking out a small triangle of tissue on the side that is too low. The base of this triangle should rest on the long incision (Figs. 261 and 262). If the nose is too short it can be lengthened by a V-shaped incision with the apex on the bridge of the nose, as recommended by Pirogoff (Figs. 263 and 264). The tissues are thoroughly loosened and the wound is sutured in the form of a Y, utilizing the principle of the Wharton Jones operation for ectropion. In this manner the tip of the nose is shoved down.

If the nose is too broad a triangular area can be excised from the upper lip with its base on the floor of each nostril and the apex near the vermilion border. This, of course, may be modified for one side if one nostril spreads more than another. Noses that are too broad and flat may be corrected by excising a V-shaped section from each ala and suturing the cartilage accurately from within the nostril. If the tip of the nose is too broad this can be corrected by taking a V-shaped section from the anterior part of each nostril (Figs. 265 and 266).

A rather common and disfiguring deformity is the so-called "saddle nose," or flattening of the bridge of the nose. This may follow trauma or disease and if marked is always accompanied by turning up of the tip of the nose. The most satisfactory operation for this deformity is the transplantation of cartilage. Carter, of New York, has had extensive experience with this operation and uses a rib or a piece of cartilage, and makes the incision either across the bridge of the nose or from within the nostril. If the tip of the nose is markedly turned up, it should be corrected by massage and after the nutrition of the skin has been developed the operation of Pirogoff in which a V-shaped incision is made and sutured as a Y may be performed for lowering the tip. The transplantation of cartilage is then postponed for at least a month. If the turning up of the tip of the nose is not very marked this can be corrected by the implantation of the cartilage. In implanting the cartilage through an external incision, which in many respects is preferable, a short incision is made across the bridge of the nose about on the level of the inner canthi of the eyes. The incision may be slightly higher or lower than this, depending upon the deformity. The periosteum is also incised and undermined until the junction of the nasal and frontal bones is reached. Over the bridge of the nose a tunnel is then made from the incision to the tip of the nose by inserting a pair of closed scissors and gradually opening them. This tunnel should be sufficiently large easily to admit the graft and to free any marked adhesions, but should extend no further on the side of the nose than is necessary. It is made between the skin and the periosteum. With a bent probe the measurement of the length of the transplant is made and cartilage is cut from the costal cartilage of a rib, near the costal arch. If possible the perichondrium on one side of the cartilage is preserved.

Fig. 259.—The denudation according to Joseph for the elevation of a drooping ala.

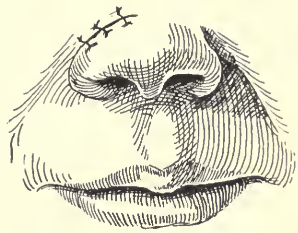

Fig. 260.—Operation as outlined in the preceding illustration is completed.

Fig 261.—Lines of incision for operation of Dieffenbach for elevation of one side of the nose.

Fig. 262.—Operation of Dieffenbach completed.

Fig. 263.—Lines of incision for operation of Pirogoff for lowering the tip of the nose.

Fig. 264.—Operation of Pirogoff completed.

Fig. 265.—Lines of incision for operation of Kolle for reconstruction of nostrils.

Fig. 266.—Operation of Kolle completed.

The cartilagenous graft is trimmed to what appears to be satisfactory shape and inserted. It is important not to trim too much at first for it is better to have it too large when first inserted than too small, as the former defect can be readily corrected. After it has been made to fit satisfactorily, the wound over the nose is closed with fine sutures of silkworm-gut or silk. A gauze dressing carefully applied or better, a cast of paraffine, which is renewed every day for a week, is used to keep the graft in position and the nose in satisfactory shape.

THE FOREHEAD

Occasionally by injury or disease the anterior bony wall of the frontal sinus is destroyed. This, if accompanied by injury to the overlying soft tissues, makes a very marked deformity. Three cases of this type that I have had were

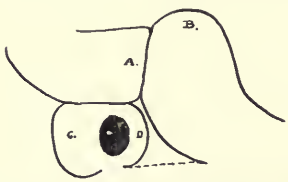

Fig. 267.—Lines of incision for closure of defect in frontal sinus of the patient shown in Fig. 270. The black area is the defect. Flaps *C* and *D* were turned in with the epithelial side inward.

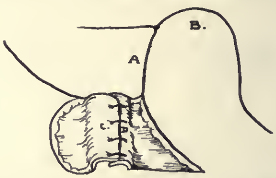

Fig. 268.—After suturing the edges of flaps *C* and *D*, flaps *A* and *B* are freed.

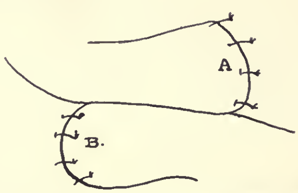

Fig. 269.—Flaps *A* and *B* are sutured as shown.

Fig. 270.—Photograph of patient E. W. S. taken before operation. The defect followed a fracture and necrosis of the frontal bone.

Fig. 271.—Photograph of E. W. S. two weeks after operation.

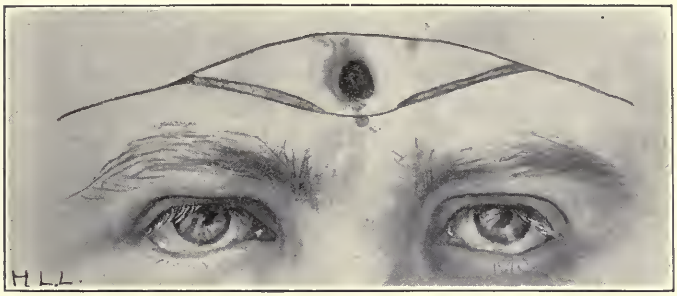

Fig. 272.—The incisions for repair of defect in the frontal sinus when there is no depression. A small flap of pericranium can be turned into the defect.

Fig. 273.—The forehead has been mobilized and the wound is sutured with a subcuticular stitch.

Fig. 274.—Photograph of patient S. H. two weeks after operation as described in the two preceding figures.

all due to trauma. To close the opening and to remedy the depression, flaps are taken from the margin of the opening into the frontal sinus, with their bases hinging on the margin. It is best to take flaps from both sides of the opening and to strip up the periosteum. Before flaps are formed or turned in, however,

a large probe is inserted into the frontal sinus and brought out into the nose and a strip of gauze is attached by a thread to the end of the probe and carried through the infundibulum opening. The gauze is drawn back and forth in order to enlarge this opening and to provide ample drainage of any exfoliated material from the inverted flap. These flaps are united with fine tanned catgut sutures (Figs. 267, 268, 269, 270 and 271). If the depression is abrupt and not very large the raw surface of the inverted flaps can be covered by a transverse incision which extends outward from each end of the defect. The whole of the forehead is mobilized by undermining, is slid down to cover the raw surface of the inverted flaps, and is sutured as a straight wound to the margin of skin just over the eyebrows. This falls in the natural crease and makes a very inconspicuous scar (Figs. 272, 273, and 274). If, however, the defect is a larger one with gradually sloping sides it will be necessary to use flaps. This can be done, as shown by the accompanying illustrations, by having the flap with its base over one eyebrow and its apex toward the hairline. This is turned down and sutured across the defect and the raw surface is covered by sliding a flap from the upper margin of the defect in the frontal sinus across, to fill up the raw surface left by removing the large flap.

TUMORS OF THE FACE

Tumors of the face are common, particularly benign tumors such as warts or moles. They are best removed by an excision which includes a small amount of surrounding healthy tissue. The defect is then repaired by utilzing some of the plastic procedures that have already been described. If the growth is a malignant one a wider margin of healthy tissue should be taken and the removal either done with an electric cautery, or else the raw surface left by the removal is thoroughly cauterized. In benign lesions, however, where a cautery is unnecessary, excision and careful suturing of the wound will leave a very inconspicuous scar. Usually such operations are performed under local anesthesia, though on account of the infiltration of the tissues a local anesthetic is not apt to be followed by as satisfactory healing as is a general anesthetic where no infiltration is necessary. The wart or mole is circumscribed by an incision, usually diamond-shaped, with the growth in the center of the area. The incision is made with a sharp-pointed knife and the cut carried through the full thickness of the skin. After the growth is removed the edges of the skin are undercut, and bleeding is controlled by clamping the vessels with mosquito forceps and tying or suturing them with fine catgut. The deeper layers of the skin are brought together with a continuous suture of fine plain catgut, tanned or chromic catgut causing too much irritation. The skin is united accurately by a continuous epithelial stitch of arterial 00000 silk. A fine subcuticular suture of silkworm-gut is also an excellent method of closure and the epithelial stitch may be used over it. (Figs. 275, 276, 277, 278 and 279.) A light compress of dry gauze is kept over the wound for twenty-four hours to prevent swelling. The stitches are removed at the end of the sixth or seventh day.

Wherever possible the long diameter of the diamond-shaped incision should correspond to, or be parallel with, the natural folds or creases of the skin. This will add greatly to the inconspicuousness of the scar.

If the growth is cancerous it should first be thoroughly cauterized with an electric cautery to prevent implantation. If a local anesthetic is used it is important to insert the needle in healthy tissue at some distance from the cancer so that the infiltrating fluid is always carried toward the growth. In this way the cancer cells will not be forced away from the cancer. If the growth is excised with a knife instead of an electric cautery the raw surface left is immediately gone over with the cautery. Such a wound may be left open for a week or longer and can then be closed or grafted. No effort should ever be made to excise a cancerous growth on the face with a knife and suture it at once merely in order to secure a good cosmetic result. Attention must first be focused on curing the cancer and after this has been apparently accomplished a plastic operation may be undertaken to provide a satisfactory cosmetic result.

Angiomas are common along the lips or on the tip of the nose. If small and circumscribed, they may be excised in the same manner as has been described for nonmalignant tumors. If they are large, a satisfactory method of

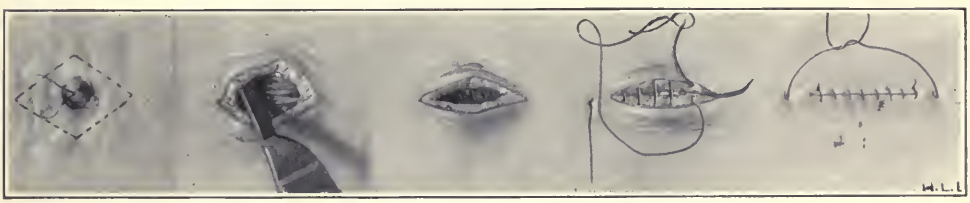

Fig. 275. Fig. 276. Fig. 277. Fig. 278. Fig. 279.

Fig. 275.—Lines of incision for excision of a benign tumor of the face. The vertical angles of the incision may be made closer to the growth.
Fig. 276.—The growth has been excised and the skin and subcutaneous tissue are thoroughly mobilized.
Fig. 277.—The superficial fascia and fat is approximated with a continuous suture of plain catgut.
Fig. 278.—The deep layer of the skin is united with a subcuticular suture of fine silkworm gut.
Fig. 279.—The epithelial layers are united with a superficial stitch of very fine silkworm gut or of arterial silk. (Epithelial stitch of Halsted.)

treatment is by the injection of hot water, which was first devised by John A. Wyeth, of New York. The water should be injected at a temperature of from 180 degrees to boiling point. Francis Reder, of St. Louis, has developed this technic in a very satisfactory manner. The principle is that the hot water destroys the endothelial lining of the blood vessels composing the angioma and causes clotting within the vessels of the tumor. In large angiomas it is best to inject at different sittings, injecting only a portion of the tumor at each sitting. If the growth is in the neighborhood of the eye or if the general health of the patient is poor, damage may be done by injecting too much hot water. Wyeth uses an all-metal syringe, which can be further heated after the water has been drawn into it. Reder finds an all-glass syringe with an asbestos plunger to be satisfactory. He uses thick gloves and injects the water as hot as possible. The tissues around the tumor are protected with moist cloths and the surface of the growth may be anointed with sterile vaseline. The point of the needle is carried well beneath

the skin before beginning the injection. When the angioma is moderately distended and the heat of the water can be distinctly felt with the bare finger on the skin, the injection should be discontinued. The needle may be removed and inserted at a different point. Several ounces of hot water can be injected at one sitting if the growth is large. Soon after injection extensive swelling may appear, which can be controlled to some extent by cold compresses. If necessary, the injection may be repeated at intervals of from two to three weeks.

THE PAROTID GLAND

The usual indications for operations on the parotid gland are tumors or a fistula. Fistulous openings come from wounds and may be so annoying that a large amount of saliva flows from the fistula during mastication, or there may be only a few occasional drops. If the fistula is in Steno's duct it is readily corrected by the operation of Deguise. A silver wire is threaded in a curved needle and passed from the external fistula through into the cavity of the mouth. The external end of the wire is threaded on another needle and also passed in the

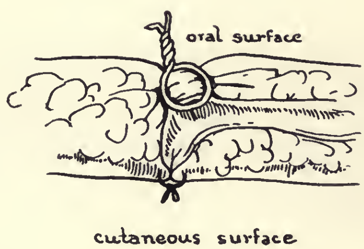

Fig. 280.—Method of Deguise for closing salivary fistula of Steno's duct.

mouth at a distance of about one-eighth inch from the point of insertion of the other end of the wire. The mouth is opened and the two ends of the wire are drawn snugly and twisted. The ends of the wire are cut short. The skin is incised around the fistula and undercut. It is sutured over the fistula with fine silkworm-gut or horsehair (Fig. 280). The wire can be left in for several weeks until the skin wound has firmly healed. The mouth should be kept clean.

If the fistula is from the substance of the gland itself a different type of operation is necessary. Probably the most satisfactory remedy for this condition is the operation of Crouse. An incision about one and one-fourth inches long is made through the skin and fat, straight downward from a point about three-fourths of an inch below the zygoma and about three-fourths of an inch in front of the ear. This incision will avoid injury to the nerves and blood vessels. The fascia covering the parotid gland is exposed and an incision about one-third of an inch long is made into the fascia, going into the substance of the parotid gland (Fig. 281). The lip on the same side as the affected parotid is grasped with gauze and the cheek turned out to expose the mucosa. A flap of mucosa about one-fourth of an inch wide and thick enough to be viable is formed, beginning near the inner border of the lip and running back to a point

just behind the level of the second upper molar tooth, the pedicle of the flap being behind (Fig. 282). A closed curved hemostatic forceps is introduced through the external incision, burrows forward close to the surface of the masseter muscles, and is forced into the mouth just in front of the pedicle of mucosa. The forceps is opened to dilate the tunnel and the end of the flap is grasped, pulled through the tunnel and fastened into the posterior edge of the incision into the fascia of the parotid gland with a fine chromic catgut suture. This suture is passed like the Lembert intestinal suture to tuck the end of the mucosa under the incised parotid fascia. The ends of this suture are left long. A mosquito forceps is then passed into the external wound and through the tunnel into the mouth, and seizes the middle of a strand of No. 5 chromic catgut, which is pulled through the wound and tied with the long ends of the fine catgut suture so as to have the ends of the stout chromic catgut in the mouth

Fig. 281.—Operation of Crouse for closure of salivary fistula of the parotid. The first incision has been made and the forceps are tunneling the tissue.

(Fig. 283). This makes the flap of mucosa assume a tubular shape around the stout chromic catgut. The external wound is closed in the usual way for skin incisions.

Tumors of the parotid may be small, round, and rather movable, or may be of a malignant infiltrating nature. The small movable tumors can usually be readily excised through a transverse incision through the skin and fascia parallel with the direction of the branches of the facial nerve. This incision is carefully carried down to the tumor and constant watch is kept for any branches of the facial nerve, not only watching for the fibers but noticing any contraction of the muscles of the face. Any suspicious strand is gently seized with a delicate forceps to test whether it will be followed by contraction of the facial muscles before it is cut. This, of course, should be carefully done because a rough handling of the branches of the facial nerve may result in their perma-

nent injury. When the capsule of the tumor is reached the tumor can usually be enucleated by blunt dissection with curved scissors, introducing the closed scissors close to the tumor and spreading them open after they have been introduced. This will gradually stretch the tissues and permit the enucleation of the growth. Bleeding points are seized with mosquito forceps and tied with fine catgut. The fascia should receive a separate row of catgut sutures before

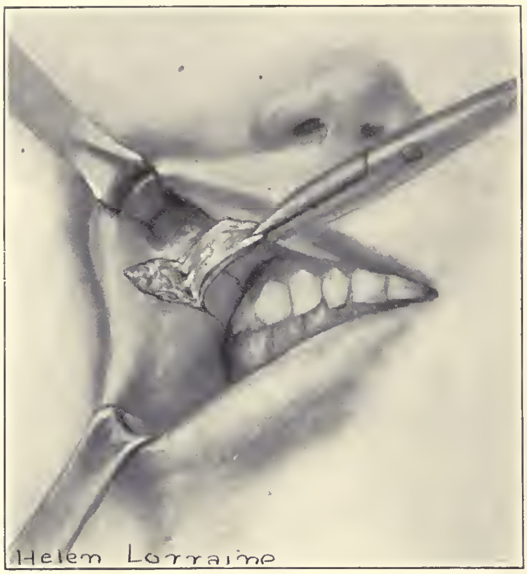

Fig. 282.—The pedicle of a flap of mucosa is formed from within the mouth.

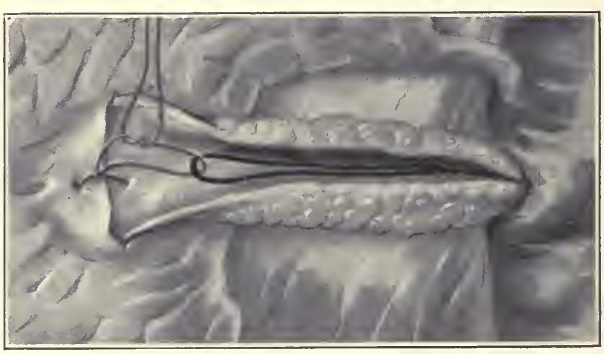

Fig. 283.—The pedicle of mucosa with its base backward has been brought through with the forceps from the external incision and is fastened into the parotid gland.

closing the skin. If for any reason the oozing cannot be controlled the wound is packed with gauze for five or ten minutes, the gauze removed and the wound closed. It may be necessary to insert a fine drain into the cavity left by the removing of the growth, but it is best to avoid this if possible because it may leave a point of dimpling in the scar or be followed by a parotid fistula.

If the tumor is large and cannot be removed by an incision immediately

over it without making the incision so long as to endanger the branches of the facial nerve, it can be approached by an incision under the angle of the jaw, which begins about the tip of the mastoid process, runs down to the level of the angle of the jaw, and then forward and slightly upward. The skin and superficial fascia are turned up in the form of a flap. The tumor in this way is approached from below and if it does not present readily at this point an incision is made into the gland substance over the tumor. This incision into the parotid should be transverse, in the general direction of the branches of the facial nerve. If the tumor is solid and the capsule strong it may be enucleated by blunt dissection, but if it is friable with a weak capsule and contains semisolid material the contents of the capsule is removed, piecemeal. The tumor should be attacked first along the anterior border, then the posterior, the dissection being carried from below upward. If fragments of the tumor are left behind they can be touched with the fine point of an electric cautery, though the burning should be made with caution to avoid injury to the facial nerve. The cavity left by the removel of a large tumor will require drainage. If sutures are necessary to check bleeding they should be of fine plain catgut so they will be readily absorbed.

In malignant growths of the parotid it is necessary to remove the entire gland along with the facial nerve. The patient should always be informed before the operation of the necessity of causing a facial paralysis on the side of the face in which the tumor is located. It is often necessary to dissect out the glands of the neck when a malignant growth of the parotid is removed, and if this is to be done the incision for removal of the parotid is so modified as to afford an ample exposure for a block dissection of either the upper portion of the neck or the whole side of the neck, according to the indications.

In malignancy in the parotid, as in malignancy elsewhere, the incision should be so shaped as to enable the operator to remove the gland and its surrounding tissues in one mass. The chief aim to be kept in mind is to cure the cancer. A straight incision is made from the zygoma just in front of the ear, downward over the anterior border of the sternomastoid muscle. If it is intended to dissect the upper triangle of the neck at the same time an incision is carried beneath the border of the jaw to the midline of the neck about one inch below the chin. The technic of block dissection of the neck is discussed in the succeeding chapters.

If the malignant growth in the parotid appears to be attached to the skin the first incision should be made at a safe distance from this point and another incision should circumscribe this area in such a manner as not to touch the tissues at this point. The lower end of the cut over the sternomastoid muscle is deepened until the external carotid artery is exposed. This artery is ligated a short distance above the superior thyroid branch. It is best to put another ligature on the external carotid just above the facial branch and to tie the facial, the lingual and the posterior occipital branches if they can be readily exposed. This not only decreases the bleeding, but on the principle of starvation of malignant growths as advocated by Dawbarn, it may somewhat retard the ten-

dency of recurrence of the cancer. The edges of the wound are then thoroughly undercut to expose the parotid and its contained growth as fully as possible. If the dissection of the parotid is undertaken with a cutting electric cautery that has a stout enough blade to allow some pressure the operation will be greatly facilitated. The parotid can then be readily enucleated with the red hot cautery by dissecting from before backward. The cautery follows readily the line of cleavage, lessens the bleeding, destroys cancer cells in its way, and closes the lymphatics which might otherwise take up cancer cells. When the temporal vessels are reached they are doubly clamped and divided with the cautery. After getting well under the parotid growth from in front and above, the cautery is pushed posteriorly, hugging the capsule of the parotid fairly closely, but taking care not to enter the capsule. The dissection is then carried down to

Fig. 284.—The operation of Sedillot for excision of the tongue.

the neck and the external carotid is again clamped and tied just below the parotid and the parotid gland and tumor are cut away with the cautery. Care should be taken in this latter step not to wound the internal jugular vein.

If a complete block dissection of the neck is necessary the incision extends from the zygoma downward over the anterior border of the sternomastoid muscle and terminates in front of the sternoclavicular joint. The dissection is made from below upward and the parotid gland is dissected out along with the mass of tissue from the neck in the manner that has just been described. The wound is closed, placing a drainage tube through a stab wound or at the lower angle of the incision, for drainage should always be used after every extensive operation for cancer.

THE TONGUE

In operations on the tongue the head should be elevated and the best possible light obtained. The rectal anesthesia of Gwathmey is very desirable, especially if the electric cautery is used.

Benign tumors of the tongue are removed by using the same general principles of operative surgery that would be applicable in benign tumors elsewhere. There are, however, special considerations on account of the function of the tongue. In a great enlargement of the tongue its size may be reduced by excision of a section along its margin. The tongue is pulled forward by

Fig. 285.—Line of incision for operation of Ashhurst for excision of the tongue.

a suture near its middle and an incision is made on the dorsal surface of the tongue parallel to its edge, and as far as may seem necessary from the edge in order to remove a sufficient amount. A similar incision is made on the under surface of the tongue and these two incisions are united in a wedge-shaped manner at the posterior ends of the incisions, at the same time making traction on the tongue toward the opposite side in order to control bleeding and to expose the tongue more readily. A wedge-shaped section is thus removed, introducing sutures as it is being excised. Sutures of fine silver wire are very

satisfactory for wounds of the tongue and may be so twisted as to prevent the ends of the wire from irritating the mucosa of the mouth.

Benign localized tumors are removed by a V-shaped incision. A tractor suture is placed through the tongue well behind the growth. A V-shaped section, including the tumor, is cut out by a sharp electric cautery. The wound is closed with fine silver wire, which is twisted, and the ends are bent to prevent irritation of the mouth. Silver wire has many advantages as a suture in this

Fig. 286.—A block dissection of the upper neck is made. · (Ashhurst.)

region. It is very slightly irritating and is mildly antiseptic. It may be left much longer than any other suture material without causing trouble. On account of the great mobility of the tongue the sutures should be left in longer than in other regions and all of them should not be removed at the same time if the wound is at all extensive. The first silver wire suture may be taken out at the end of about twelve days or two weeks from the time of operation.

Complete excision of the tongue for cancer is not so frequently done as formerly because with careful dissection with the electric cautery total removal is

frequently unnecessary. There are many different operations for removal of the tongue. That method should be chosen which appears to lend itself best to the purposes of a block dissection not only of the tongue and its adjacent tissues but of the tissues of the neck. Dissection of the tongue with electric cautery is always done wherever possible, particularly in cancerous affections, not only because it lessens bleeding but because it diminishes the chances of recur-

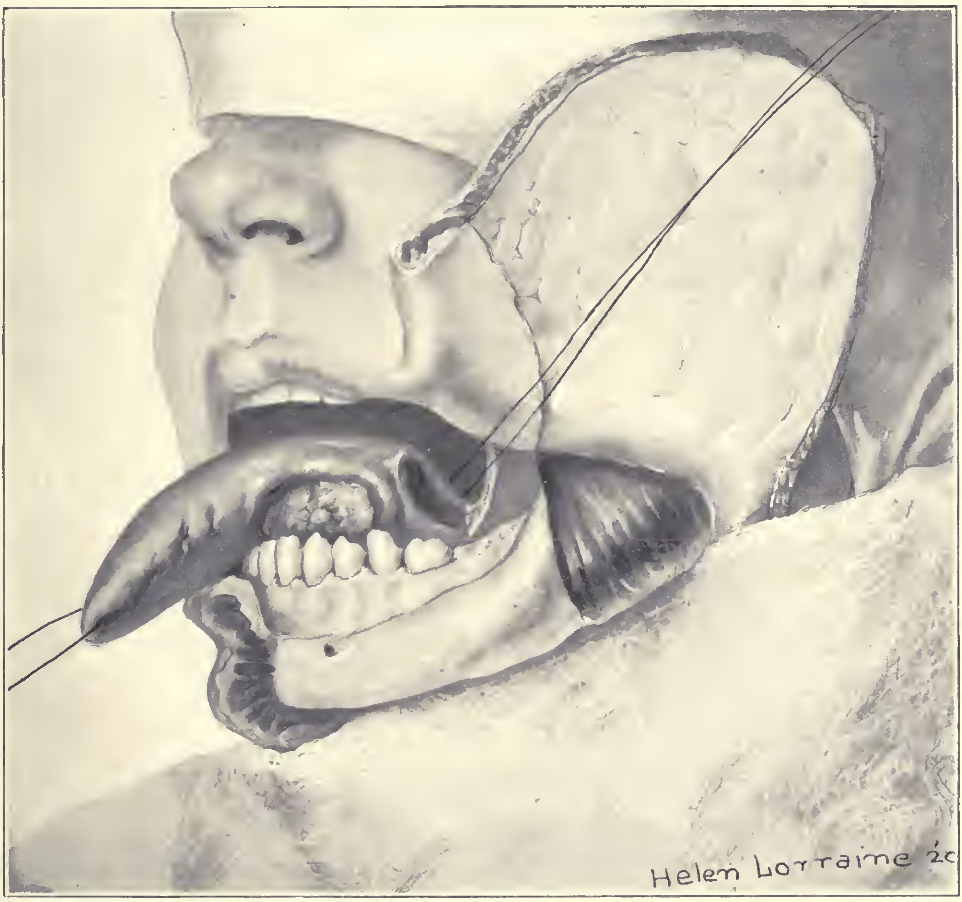

Fig. 287.—The incision has been continued to the cavity of the mouth, the flap has been reflected, and excision of the tongue is being completed. (Ashhurst.)

rence. If there is an ulcerated lesion it should be thoroughly cauterized as the first step in the operation in order to prevent implantation of cancer cells.

The question of anesthesia in these cases is highly important. If the cautery is to be employed it is dangerous to use ether about the face. The rectal anesthesia of Gwathmey is excellent here. A malignant lesion that is sufficient to demand excision of the tongue will also require dissection of the neck. It is best to do this first as it enables the surgeon to control the blood supply of the tongue by ligating the lingual or the external carotid artery, and at the

same time it subjects the patient to the dangers of inhalation pneumonia during only that portion of the operation in which the mouth cavity is entered to remove the tongue.

According to the method of Sedillot, a median incision is made in the lower lip, chin and neck as far down as the hyoid bone. The lower jaw is divided with a saw in the midline and the two halves of the jaw are pulled apart. The tongue is pulled out with a tractor suture and the mucosa in the floor of the mouth is divided from before backward (Fig. 284). If the lingual artery has not been previously tied during the neck dissection it is recognized as lying between the hyoglossus and genioglossus muscles and is clamped and tied. The hyoglossus and mucosa behind it are divided with cautery while making traction on the tongue. If the disease extends to the palate or pharynx the affected tissue in this neighborhood is excised in one mass if possible. The base of the tongue is divided, preferably with a cautery, taking care to preserve as much muscle and as many nerves as possible so as not to interfere too greatly with deglutition, but at the same time going a reasonable distance from the cancer. The bone is drilled and wired together. The patient is kept in the Trendelenburg position until he is able to sit up.

The operation of A. P. C. Ashhurst is designed to combine a block dissection of the neck with excision of the tongue. An incision is first made from the chin downward to the hyoid bone and then backward to the tip of the mastoid process (Fig. 285). The lower edge is retracted and the upper portion of the neck is cleared with a block dissection from below upward leaving the tissues attached to the upper skin flap. The dissection extends from below the bifurcation of the common carotid to the floor of the mouth. It reaches the muscles of the neck and the hypoglossal and superior laryngeal nerves (Fig. 286). The neck wound is packed with gauze and the anterior end of the incision is prolonged through the midline of the lower lip into the mouth. This forms a flap which is dissected backward, so exposing the tongue. The tissue of the block dissection of the neck is then cut away from this flap. The tongue is held forward by a tractor suture. The mucous membrane between the lip and the lower jaw is divided with scissors or cautery from before backward. The masseter muscle is not cut. Another tractor suture is now passed through the glosso-epiglottidean fold, which facilitates drawing the tongue forward. The frenum of the tongue is divided and the dissection continued backward on the other side of the tongue, separating the tongue from the floor of the mouth, first on the side opposite to the disease and then on the diseased side (Fig. 287). The anterior pillow of the fauces is divided on both sides, the tongue is drawn well out. It is cut across at its base at least three-fourths of an inch beyond the visible signs of cancer on the diseased side and then on the healthy side backward along the floor of the mouth to the transverse section of the diseased side. The lingual artery on the healthy side is watched for and caught. The tongue is then completely cut across and the stump of the tongue is sutured to the mucosa that may still be remaining on the inner side of the alveolar process of the lower jaw or from the inner side of the cheek. Wherever possible the

raw surface is covered by mucosa. After the completion of the operation a few buried sutures attach the cheek to the body of the jaw. The skin wound is accurately closed and a rubber drainage tube is inserted at the most dependent portion of the external incision. Ashhurst[3] advises the removal of all the molar teeth on the diseased side of the tongue before the wound is sutured as well as the corresponding alveolar process of the lower jaw if it seems at all likely that this has been affected by the cancer.

The method of excision of the tongue practiced by Blair[4] is well conceived and will probably replace other operations for advanced cancer of the tongue.

Fig. 288.—Line of incision in operation of V. P. Blair for excision of tongue in advanced cancer. A tracheotomy had been done several days previously.

He advises a low tracheotomy, preferably done under local anesthesia one or two days before the operation on the tongue (Fig. 288). The incision begins behind the angle of the jaw, curves downward to just below the lower border of the hyoid bone in the midline, and is carried upward behind the angle of the jaw on the other side of the neck to a point corresponding with its beginning. The incision is carried through the platysma muscle and the upper flap, consisting of skin and platysma, is dissected from the deep cervical fascia to the lower border of the jaw. The facial vessels at the lower border of the jaw

[3]Ashhurst, A. P. C.: Ann. Surg., 1915, lxii, 238-245.
[4]Blair, V. P.: Surg., Gynec. & Obst., February, 1920, pp. 149-153.

are doubly clamped and divided. The facial vein is doubly clamped and divided on the level with the skin incision. The submaxillary gland is drawn upward and the facial artery is doubly clamped and divided just as it enters the gland and as far as possible from its origin (Fig. 289). The artery is tied and the branches within half an inch of its end are also tied. Blair thinks it is important to leave a long stump of the facial artery with its branches ligated in order

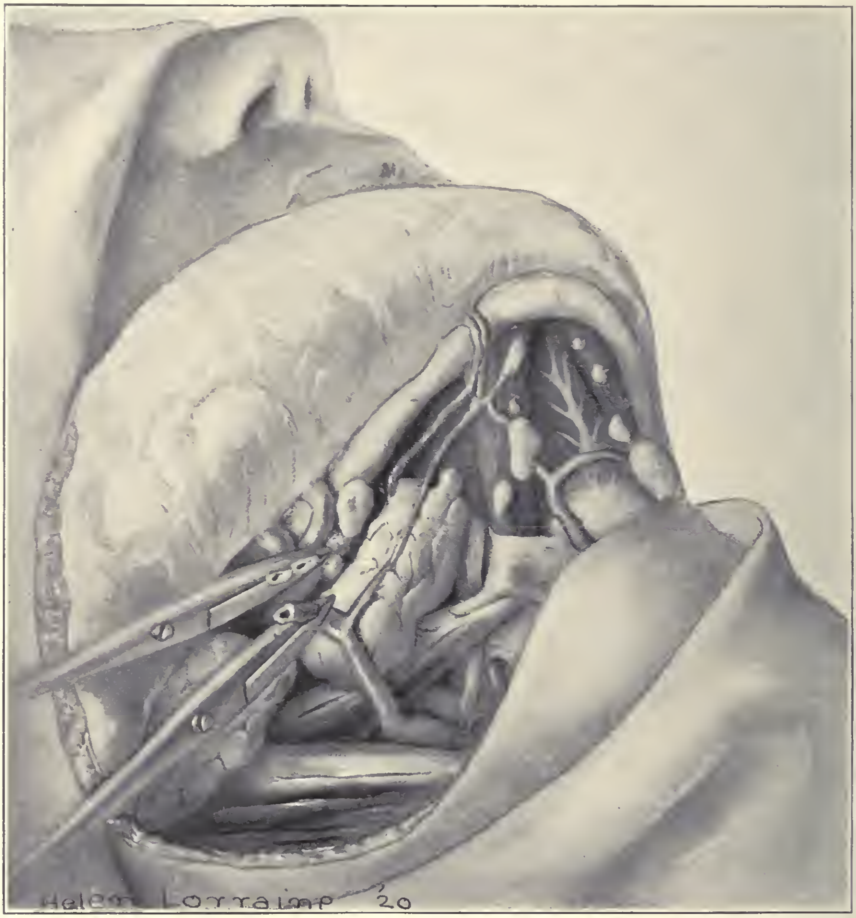

Fig. 289.—The dissection of the neck is begun and the facial vessels are doubly clamped and divided.

to prevent secondary hemorrhage. The submaxillary gland with its surrounding tissue is dissected out. Behind the upper and outer part of the digastric tendon the fibers of the hyoglossus muscle are separated bluntly and the lingual artery is exposed and tied. The submaxillary gland with its surrounding tissue having been removed on each side and the blood controlled, the muscles beneath the symphysis are divided with a sharp electric cautery. The periosteum and mucous membrane are stripped from the inner surface of the jaw and the cancer, if an ulcer, is thoroughly cauterized. The tongue is drawn through the open-

ing beneath the symphysis of the lower jaw. This exposes the pharynx. The tongue is severed with an electric cautery at the hyoid bone. The lower portion of each parotid gland is also removed, preferably with the cautery. The lower border of the digastric muscle on each side is sutured to the sternomastoid muscle with fine tanned catgut. The stumps of the facial artery are left standing out free into the pharynx. By having a long stump and tying

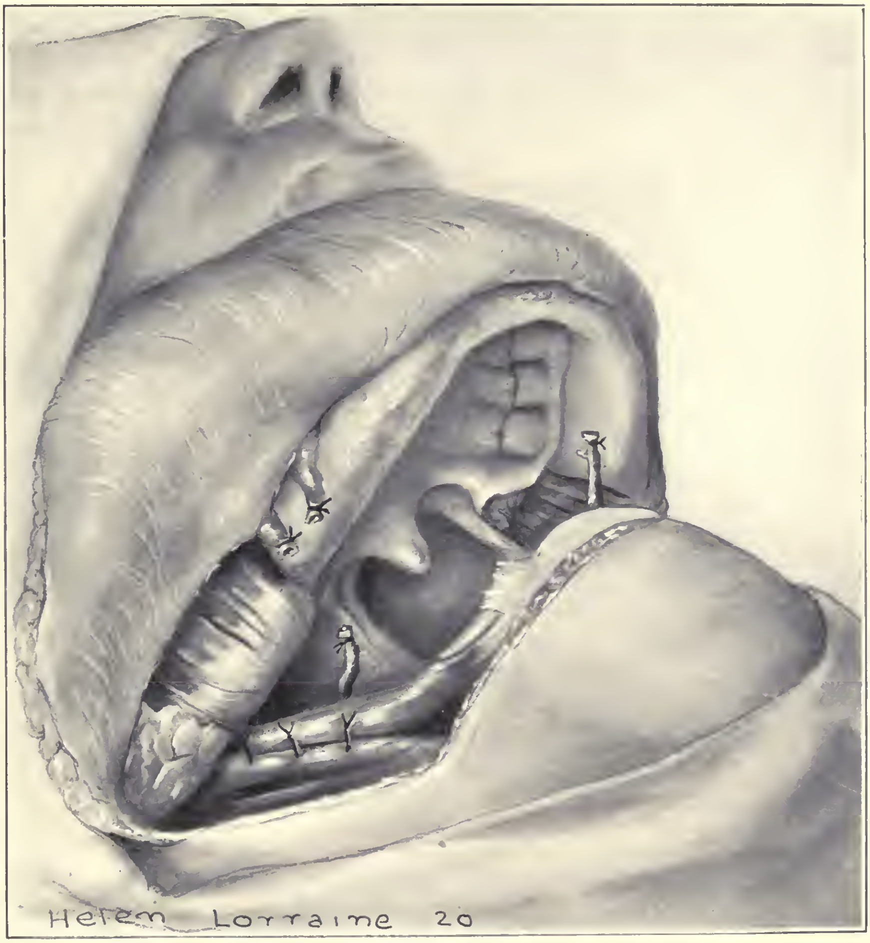

Fig. 290.—Operation of Blair completed, except suturing the wound.

the little branches there is rarely secondary bleeding from the facial (Fig. 290). For feeding purposes a catheter is passed through one nostril into the pharynx and fastened to the upper lip by adhesive plaster or a suture. This is done before the wound is closed as the larynx drops back after the operation and makes it more difficult to pass the catheter into the esophagus. The wound is closed with silkworm-gut. The tracheotomy tube is left in for a week or ten days until danger of edema of the larynx is passed. The day before its removal it is plugged with a cork to test whether the patient can breathe satisfactorily through the larynx.

UPPER JAW

If a growth is limited to the alveolar process it may be removed by first cutting the mucosa and stripping it back to the point at which the section of the bone is to be made. The bone is removed by a small sharp chisel or a small finger saw. Schlange's method is to drive several gouges in the proposed line of resection of the alveolus and leave them in position to control hemorrhage until the last gouge is driven in to separate the final attachment. Then the wound is quickly packed. If a solution of epinephrin is injected into the mucosa before the incision is made the bleeding is greatly diminished and the operation is facilitated.

Fig. 291.—Lines of incision for operation of Weber for excision of upper jaw.

Excision of the upper jaw is done for malignant tumors. A number of incisions have been devised as it was a standard operation of preantiseptic days. Probably the most satisfactory incision for excision of the upper jaw is Weber's. This begins at the inner canthus of the eye, goes downward in the groove between the nose and cheek, skirts the ala of the nose, curves inward to the midline of the upper lip and divides the upper lip vertically (Fig. 291). From the upper extremity of the incision a slightly curved cut is made outward following the lower margin of the orbit. The flap is reflected outward and the superior maxillary bone is exposed. Unless the indications of the operation demand it, it is best to leave the orbital plate of the superior maxillae, but if this cannot be safely preserved the periosteum should be stripped up and the orbital contents lifted gently upward and outward with a retractor. The

malar bone is divided with forceps or a wire saw, and then the nasal and orbital processes of the superior maxilla are divided at the inner and lower portion of the orbit. The mouth is opened and an incision is made in the hard palate along the midline or parallel to it. The middle incisor teeth are removed and with a finger saw the hard palate and alveolar process are divided from within the nostril. The soft palate is separated from the hard palate with scissors. The superior maxilla is then seized with heavy forceps and bent outward and with a twisting motion is removed, cutting any attached strands of tissue. The cavity caused by its removal is at once packed with dry gauze which is firmly pressed in position and held for four or five minutes. It is gradually removed and any bleeding spots that can be clamped are caught and tied. The

Fig. 292.—Lines of incision for operation of Binnie for excision of the upper jaw when the skin is involved.

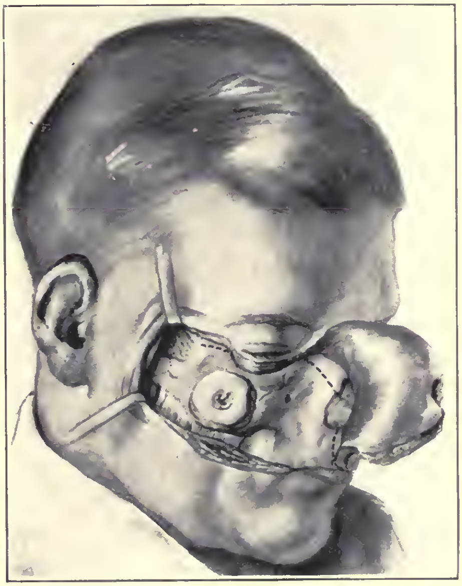

Fig. 293.—Reflection of flap in operation of Binnie for excision of upper jaw.

wound is packed with iodoform gauze and the reflected flap is sutured into position. Multiple ligations of the external carotid artery before excising the jaw lessen bleeding and probably decrease recurrence.

The patient is put to bed with the head turned toward the operative side and the wound in the mouth is kept clean by frequent spraying with mild antiseptic solutions or by irrigating it with the patient turned in such a position that the fluid readily runs out.

If the growth in the upper jaw involves the skin the incision of Weber cannot be satisfactorily applied. An excellent incision for cases of this type is that of Binnie. According to his method incisions are made around the tumor in healthy skin as close to the growth as is thought wise. The upper junction of these incisions is joined by another incision that begins at the

nose just below the inner angle of the eye and from the lower junction an incision goes almost to the angle of the mouth (Fig. 292). The flap with the nose and upper lip as base, is dissected and retracted inward and the outer incisions around the growth are undercut and retracted outward (Fig. 293). The bone is then removed in the same manner as described after the incision of Weber.

In squamous cell cancer involving the eye and upper jaw frequently a typical operation cannot be done. The growth should first be cauterized thoroughly with a thermocautery and circumscribed with an incision a safe distance from the margin of the cancer. Dissection is then made to remove the neoplasm and the tissues immediately around it in one mass so far as possible. The raw surface remaining should then be cauterized with a thermocautery and the plastic operation that may be indicated is undertaken at some subsequent time after the sloughs have separated.

A temporary osteoplastic resection of the upper jaw in order to gain access to a tumor in the pharynx can be done much along the same line as indicated in the Weber operation except that the jaw bone is left attached to the flap and is reflected along with the flap. After the operation has been completed the flap with its attached bone is replaced. In this operation it is not necessary to remove the lower plate of the orbit which is separated from the rest of the superior maxilla by a sharp chisel.

LOWER JAW

Tumors of the lower jaw along the alveolar process may be removed in the same manner as similar tumors of the alveolar process of the upper jaw. The lower jaw is somewhat more accessible than the upper jaw and often permits the use of a small rotary saw which greatly facilitates the operation. Holes may be drilled in the proposed line of incision and the section of bone removed with a small thin chisel. In growths that spring from the sockets of the teeth it is necessary to destroy or remove the lining of the tooth socket, else a recurrence is probable. This can sometimes be done by the point of a sharp electric cautery and may prevent a loss of considerable bone substance.

In resection of one-half of the inferior maxilla an incision may be made as described in the Ashhurst operation for excision of the tongue. The lower jaw can usually be removed, however, by a less extensive incision, which begins at the chin, goes downward and backward just below the lower border of the jaw, and then curves slightly upward behind the angle of the jaw. The facial artery is clamped, divided and ligated. The amount of tissue that should be removed along with the lower jaw depends upon the indication for the operation. If the cancer presents a raw surface within the mouth this should be thoroughly cauterized with a thermocautery before making an incision. The soft tissues are loosened from their attachments along the margins of the incision and the middle lower incisor teeth are extracted. The bone is divided in the midline or at the point desired by a wire saw after the soft parts have been

separated in this region and protected from the saw. The bone is pulled downward and outward and its attachments to the muscles and to the mucosa are separated from before backward. The coronoid process is divided unless it is distinctly involved in the growth and the masseter muscle and the parotid gland are dissected from the ramus of the jaw. The head of the bone is torn from its articulation with a twisting motion. Bleeding points are tied and the mucosa within the mouth is approximated if possible. Drainage with a tube in a stab wound is provided. The after-treatment is similar to that after excision of the upper jaw.

Partial resections of the jaw may be indicated for malignancy of the jaw itself or for cancer of the floor of the mouth. When cancer involves the floor of the mouth and under surface of the tongue a free dissection of the floor of the mouth is essential to cure. If provision is not made for a resection of a part of the lower jaw the resulting wound is difficult to heal. It is best to re-

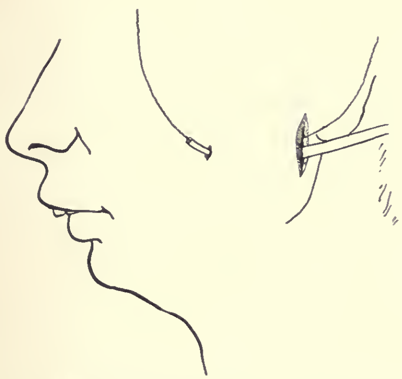

Fig. 294.—Operation of V. P. Blair for correction of retracted chin. The first incision has been made and a silk ligature is passed, to which a wire saw will be fastened.

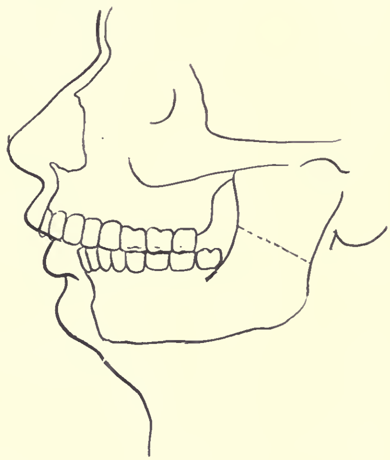

Fig. 295.—The line of incision of the lower jaw is shown.

sect a portion of the jaw to permit the jaw bone to collapse at this point until healing has occurred. Later the tissues may sometimes be stretched and a plastic operation with transplantation of bone is occasionally possible. The bone is divided in the midline, as though a resection of one-half of the inferior maxilla were to be done. The tissues are divided with electric cautery keeping close to the bone and making a block dissection as far as possible. That portion of the inferior maxilla to which the growth is nearest is removed along with the growth, dividing the bone with a wire saw. This permits the space in the floor of the mouth to collapse and healing takes place more readily than if the bone were kept intact. The principle is the same as that of multiple excision of the ribs in chronic empyema.

After excision of either the upper or the lower jaw a competent dentist should be consulted so he can provide the proper prosthetic devices to prevent deformity as far as possible.

Blair has developed operations for correction of deformities of the lower jaw. When there is marked retraction of the chin from lack of development of the bone he divides the bone through an incision about three-fourths of an inch long through the skin over the posterior border of the lower jaw in front of the lobe of the ear. The parotid sheath is opened at the anterior border of the gland and the gland is drawn backward until the posterior border of the ramus of the jaw can be felt. A curved pedicle needle with the eye at the end and threaded with heavy silk, is passed through this incision between the parotid gland and the masseter muscle, going behind the ramus of the jaw and hugging the bone closely. The point of the needle emerges through the skin of the cheek in front of the ramus of the jaw without penetrating the mucosa of the mouth (Fig. 294). The silk is withdrawn and fastened to the end of a wire saw which is pulled through and which divides the ramus of the jaw horizontally (Figs. 295 and 296). The hemorrhage is controlled by packing

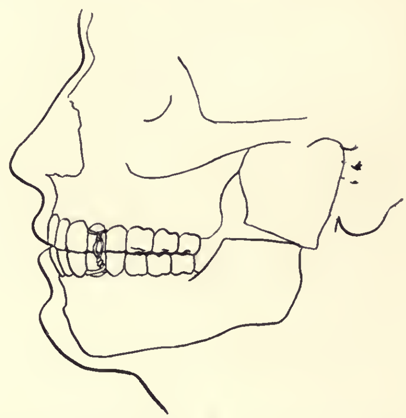

Fig. 296.—The ramus of the lower jaw is completely divided and the jaw is brought forward and fastened in its corrected position by wires to the teeth.

the wound with gauze. A similar procedure is carried out on the other side and the teeth of the lower jaw are wired to the teeth of the upper jaw in such a position as will insure satisfactory articulation and forward advancement of the lower jaw. It will be necessary to stretch the muscles considerably in order to accomplish this.

If the jaw is too long, sections may be removed from each side near the angle of the jaw and the bone reunited by sutures through drill holes that have been made previously to the resection of the bone. Such operations should only be undertaken with the cooperation of a good dentist who is interested in this work.

In ankylosis of the temporomaxillary joint, the head of the bone on the affected side may be resected if it has been determined that the ankylosis is dependent upon this joint. The operation described by Murphy, or some modification, is satisfactory. It must first be ascertained which side is affected. This can usually be done by careful observation and noting that there is a

slight sliding motion forward of the jaw bone on the unaffected side as the patient attempts to open his mouth. The muscles on the ankylosed side are usually more atrophied than on the unaffected side. The operation of J. B. Murphy is done through an L-shaped incision which begins in the temporal region above and in front of the ear and goes downward to the posterior portion of the zygoma, curves forward along the upper border of the zygoma for about three-fourths of an inch and then goes slightly upward so as to avoid the branch of the facial nerve (Fig. 297). This flap of skin and fascia is reflected upward and the neck of the condyle of the lower jaw is exposed. Murphy uses special retractors for this purpose. The internal maxillary artery passes in-

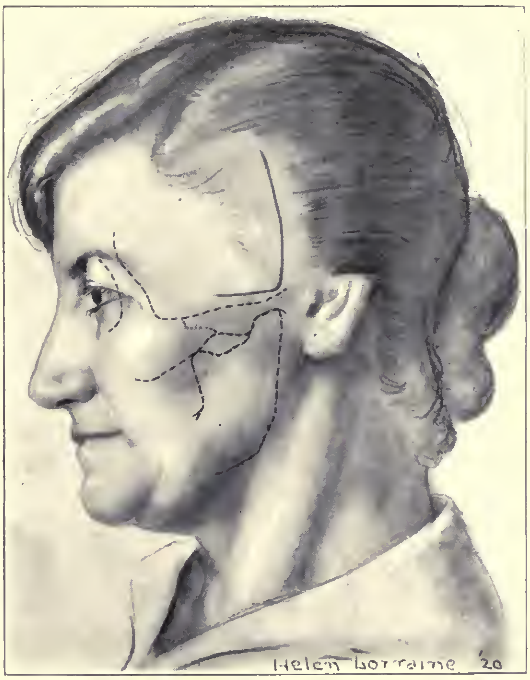

Fig. 297.—The lines of incision and the outline of the bony skeleton for approach to the temporomaxillary joint according to J. B. Murphy.

ward behind the neck of the condyle of the lower jaw and close to the bone, and it is necessary to protect this vessel by small, deep retractors. The neck of the bone is divided with a wire saw and a half-inch section of bone is removed. This may be done with forceps or a chisel instead of a saw. A flap of fat and fascia from the temporal muscle is then dissected with the base downward and is tucked in between the divided ends of the neck of the condyle and securely fastened in this position by buried sutures of tanned catgut.

The disadvantages of Murphy's operation are that in prolonged ankylosis the muscles are frequently contracted or atrophied so that even after division of the bone it is difficult for function to be reestablished. When the tissue changes about the joint and the coronoid process are extensive, operations on

the temporomaxillary joint alone will not avail. Here the operation often known as Esmarch's operation, in which a triangle of bone is removed from the lower jaw near its posterior angle, gives excellent results. In this operation an incision about two and one-half or three inches long is made, beginning just above the lower angle of the jaw and, extending along its lower border. This is made while drawing the skin upward so that the scar will not be conspicuous. The facial artery is divided or retracted. The soft parts are separated from the bone on the inner and outer surface. The periosteum is divided along the proposed lines of the resection and a triangular or wedge-shaped piece of bone having its apex at the posterior portion of the alveolar process is removed with a rotary saw or a wire saw. The base of the wedge which is just in front of the angle of the jaw is about one and one-fourth inches long (Fig. 298). In a child the base of the wedge would be proportionately less. When the bone

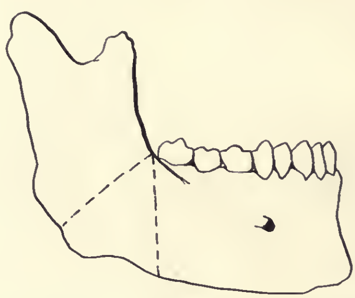

Fig. 298.—Lines showing the excision of bone for the Esmarch operation.

is resected the inferior dental artery and nerve are divided. Hemorrhage is controlled by packing or, if necessary, by the application of bone wax. A flap of tissue from the masseter muscle may be sutured in the defect in order to prevent bony union. The wound is closed without drainage. Care is taken to avoid wounding the mucosa of the mouth.

PERIPHERAL OPERATIONS ON THE FIFTH NERVE

Neuralgia of the trifacial nerve may require operation for resection of its peripheral branches. It is probably true that in genuine tic douloureux peripheral operations or injections of alcohol are never permanently curative. However, they may give relief for several years and if the patient desires this type of operation with the assurance that it will in all likelihood not be a permanent cure it should be done. Peripheral resection of the supraorbital branch of the trifacial nerve can be done through an incision in the eyebrow, which leaves no disfiguring scar. The nerve is exposed, grasped with forceps, and firm and steady traction is made continuously by slowly twisting over the forceps, and the nerve is extracted. In this way a considerable length of the nerve is removed. The foramen from which the nerve has been removed is plugged with a piece of neighboring periosteum or soft tissue which is packed into the foramen with

the end of a probe. A metal screw or irritating foreign substances should never be used to occlude a foramen from which a nerve has been removed.

Operations upon the second or superior maxillary division of the fifth nerve can best be done within the mouth. An external incision is unnecessary and is very disfiguring. The lip and outer angle of the mouth are forcibly retracted upward and a weak solution of epinephrin is injected freely into the mucous membrane and tissues around the infraorbital foramen. A transverse incision of about one and one-fourth inches is made through the mucosa where it is reflected from the bone to the inner surface of the cheek. This incision is carried down to the bone. The periosteum is elevated with a periosteal elevator up to the region of the infraorbital foramen. This point

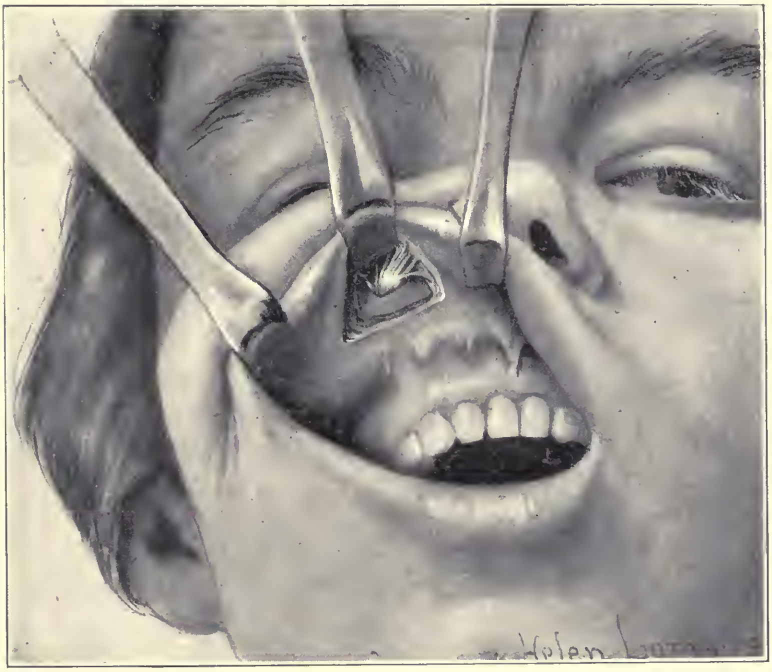

Fig. 299.—Incision for resection of second division of the fifth nerve from within the mouth.

is marked by the finger on its approximate location just below the lower eyelid. When the foramen is seen the periosteum is stripped up freely around it and the nerve is recognized emerging from the foramen (Fig. 299). The nerve is caught with a pair of hemostatic forceps and gradual traction is made over a period of several minutes.

Two inches or more of the nerve can be extracted in this way. The foramen is plugged with a piece of neighboring periosteum. The incision in the mucosa is sutured. A gauze compress is placed over the cheek and fastened firmly for twenty-four hours in order to prevent oozing and swelling.

The third division of the fifth nerve is more difficult to reach but can be operated upon from within the mouth. The mucous membrane and tissue

over it in the region of the proposed incision are infiltrated with a weak solution of epinephrin. An incision about one inch long is made internal to and parallel with the anterior border of the ascending ramus of the lower jaw, the mouth being held well open with a gag. The periosteum is stripped up from the bone until the inferior dental spine is felt and the ligament of the jaw which is attached to this spine is divided with scissors. The nerve is just behind this and is hooked up into the wound and as much of it as possible is removed by gradual traction.

CHAPTER XV

OPERATIONS ON THE SCALP, SKULL AND BRAIN

Operations on the scalp, independent of incisions of the scalp as a preliminary step in operations on the brain, are not often indicated except as a result of trauma or for benign tumors. Injuries of the scalp are frequent. They are treated by immediate disinfection and if the wound is a ragged one it is excised and the margins are sutured. Shaving or closely clipping the hair in the region of the wound should always be done as a first step. The scalp presents a somewhat peculiar structure which renders the approximation of its wounds or the ligation of its blood vessels different from ordinary tissues. The skin of the scalp is thicker than in other parts of the body and is intimately adherent to the superficial fascia which attaches it firmly to the aponeurosis and muscle just beneath it. This aponeurotic layer of fascia, called the galea aponeurotica, covers the vertex of the skull and connects the muscular portions of the occipitofrontalis muscle. It is also continuous with the temporal fascia below the temporal ridge. It is in reality a deep fascia, though it is peculiarly firmly attached to the skin. The edges of the wound in the scalp which do not involve the galea do not retract. The blood vessels run in the deep layers of the skin and lie in very dense tissue to which they are adherent. It is difficult to pick up the vessels in the scalp and bleeding is arrested by sutures which are tied tightly enough not only to approximate the tissues but to control bleeding. If the galea is wounded it is necessary to include this in the sutures. Infection of the space of tissue beneath the galea and between this fascia and the pericranium is dangerous, as the tissue here is loose and infection may spread rapidly. A large hematoma can collect between the galea and the pericranium. The pericranium is tightly attached to the sutures of the skull, but adheres very lightly to the surface of the bone elsewhere so that infection beneath the pericranium will probably be limited to one bone of the skull whereas infection between the pericranium and the galea aponeurotica can spread over the whole scalp.

In approximating wounds of the scalp it is highly important to unite the galea accurately in order to obtain a satisfactory adjustment of the scalp wound. If the galea is not united the wound will gap and union of the scalp will be unsatisfactory. If the galea is united the margins of the skin of the scalp will fall so close together that frequently no other sutures are required. In incising the scalp in surgical operations, instead of grasping the individual vessels, which has been explained as being difficult without damage to the skin, the galea is seized among the margins of the incision with long heavy hemostatic forceps and the forceps are turned outward and held out of the operative field. They

will thus serve to draw the galea up and so compress the divided vessels in the skin of the scalp that complete temporary hemostasis is obtained. When the operation is completed permanent hemostasis is secured by sutures.

Sebaceous cysts of the scalp are common. They sometimes grow to a considerable size and are called "wens." They are easily excised by a straight incision, or by an elliptical incision which includes an oval mass of the thin redundant skin. The sac is removed by blunt dissection, inserting closed scissors along the outer surface of the cyst wall, hugging it closely and opening the scissors widely each time after they are inserted. If the cyst has been wounded its edges are grasped with hemostatic forceps and the cyst is lifted out. All of the cyst wall must be removed, otherwise there will probably be a recurrence.

A cirsoid aneurism of the scalp is an enlargement of the normal arteries together with a growth of new arteries. It is treated most satisfactorily by ligation and excision. The vessels are ligated in what appears to be a normal area. If the growth is not too large excision can then be attempted. It has been suggested to follow the method of Wyeth of injecting hot water by isolating the main trunk of the vessels, ligating the central end, and injecting into the distal end hot water, which will destroy the endothelial lining of the vessels. Of course, caution is necessary to isolate the other branches from the main trunk so that the hot water will course as far as possible through the region of the cirsoid aneurism. If the temporal arteries can thus be isolated this operation has something to commend it, but the farther the point of injection of hot water is from the origin of the abnormal vessels, the more danger there is of injuring healthy tissue. Of course, this should never be tried if the healthy vessels cannot be reached lower than the upper portion of the external carotid artery.

Excision of small angiomas or affected areas of the scalp is done on general surgical principles, suturing the wound in due regard to the peculiar structures of the scalp that have already been discussed.

Operations upon the skull are seldom indicated except as the skull may be involved in extension of a lesion from the scalp or more frequently in order to gain access to the brain. As all operations upon the brain except in very young infants require opening of the skull this operation is described as an essential preliminary part of operations upon the brain. The older method of trephining in which a button of bone was removed from the skull by a trephine, is but seldom used. If a lesion of the brain is extensive enough to demand an operation, it usually requires much wider exposure than can be obtained through a trephine. Besides, in the use of a large trephine there is danger of injuring the dura because of the irregular thickness of the skull, which might render the skull at one part of the trephine opening considerably thinner than at another portion. Opening the skull with a mallet and chisel inflicts an unnecessary amount of trauma upon the brain, which is already diseased or no operation would be indicated. The most satisfac-

tory method is through a hole drilled by a burr of such construction that, like the Hudson instrument, it stops automatically when the dura is reached; or a burr of conical or spherical shape that goes through the skull first at the central point can be used. Here the thin margins of bone next to the point of penetration are removed by a sharp-pointed elevator and the dura is separated from the bone in the region of this opening by a dural elevator or a bent probe. The opening is enlarged with rongeur forceps, or with forceps of the DeVilbiss type, which cut a narrow path.

In making an osteoplastic flap for approaching the brain the location of the flap is first outlined by scratches with the knife. It is so situated that the supposed center of the lesion will about correspond to the center of the osteoplastic flap, and it is planned with due regard to the nutrition of the flap. The base of the flap should include some branches of the temporal or occipital arteries and its apex should point toward the vertex of the skull. A tourniquet on the scalp may be used though this is usually unnecessary. Bleeding is best controlled by a firm pressure along the line of incision with the fingers of an assistant, making the incision down to the skull for about two inches and then controlling the bleeding by catching the galea with long hemostatic forceps and turning the forceps back, as has already been described.

The first section of the incision is made on each side of the base of the flap. A periosteal elevator is then run under the base of the flap as close to the skull as possible from the lower end of one of these incisions to the other and the tissues are elevated. A light strip of metal is thrust under the flap and another placed external to the base of the flap and the ends are compressed by a rubber band, or long soft-blade forceps, such as are used in stomach or intestinal suturing, may clamp the base of the flap. In this way hemorrhage from the flap itself is controlled during the operation and at the same time but little of the attachment of the scalp to the bone is affected. The incision following the scratched line already made is completed in sections with but little loss of blood. The scalp should not be detached from the bony portion of the proposed osteoplastic flap and the pericranium should be stripped up away from the flap. The skull is perforated by a burr at any point along the line of incision, though it should be as far as possible from the site of the meningeal vessels. The rest of the procedure may be carried out in several different ways. A series of holes can be made with the burr along the line of incision for the osteoplastic flap and these holes are connected by a DeVilbiss forceps, or by a wire saw, which is carried under the skull from one perforation to another. The dura is protected by a grooved director beneath the saw while the skull is being divided. A very satisfactory method is to make only one perforation and cut the rest of the skull with a DeVilbiss forceps. When the skull is thick this may be a laborious process. If there is reason to expect close adhesions between the dura and the skull many perforations with a burr are made and the dura is separated as far as possible between these perforations before the rest of the skull is divided. By far the quickest and least laborious method is with the rotary saw. This may be dangerous unless

handled with considerable care. It should never be used without a guard and the saw with the guard is started from a perforation that has been made with a burr. Even with the guard, however, the dura will be occasionally injured. The bony part of the flap near the base is divided beneath the scalp as far as possible, taking care not to injure the soft tissues at the base of the flap in order that the nutrition of the bone may be maintained. The base of the bony flap is fractured by inserting a periosteal elevator under the bone at the apex of the bony flap and prizing up the bone. After elevating it for a short distance other elevators are inserted farther down on the side of the bone flap and with a quick jerk the base of the bone flap is fractured. The scalp and the bone of the flap are wrapped together with gauze wrung out of salt solution, taking particular pains not to separate the soft tissues from the bone.

If bleeding occurs in the bone it is checked by pressing into the bone some bone wax. This consists of a mixture of beeswax seven parts, almond oil one part, and salicylic acid one part and serves mechanically to stop the bleeding by filling up the channels in the bone which contain the blood vessels.

The incision in the dura depends upon the character of the pathology present. If the lesion can be seen through the dura before the dura is opened the incision is made in such a manner as to expose it most satisfactorily. If the tumor or cyst is located beneath the cortex of the brain a flap of dura is made with the base corresponding to the base of the osteoplastic flap. The incision in the dura should not be nearer the bone than half an inch. After the operation is completed the dura is sutured with continuous sutures of fine silk or fine catgut.

The location of the flap is, of course, dependent upon the location of the lesion and this in turn is determined with regard to the special centers in the brain. The region of these centers is determined by measurements on the surface of the skull. The old well-established method is that of Chipault. This requires working out in each case the percentage distances between the nasion and the inion. The nasion is the median part of the junction of the nasal and frontal bones and the inion is the external occipital protuberance. According to the method of Chipault a line is drawn along the middle of the scalp from the nasion to the inion. This line, considered as 100, is divided into percentages. The top of the fissure of Rolando is 55 per cent of the distance from the nasion. The three primary lines of Chipault are drawn, one from the retro-orbital tubercle, or the malar tubercle as it is sometimes called, to the Sylvian point, which is 70 per cent of the distance from the nasion to the inion; the second is the lambdoidal line which runs from the malar tubercle to a point at 80 per cent of the distance from the nasion to the inion in the midline; and the third is the lateral sinus line, which marks the lateral sinus and runs from the malar tubercle to a point that is 95 per cent of the distance from the nasion to the inion. These three primary lines are divided into tenths of their length. Two secondary lines are drawn, one of which, called the precentral line, passes from the junction of the second and third tenths of the Sylvian line to the precentral point at 45 per cent of the distance from the nasion to the inion in the midline; and the

Rolandic line which passes between the junction of the third and fourth tenths of the Sylvian line to the Rolandic point which is 55 per cent of the distance from the nasion to the inion. The precentral line begins at the bifurcation of the Sylvian fissure, and lies in its upper two-thirds over the precentral fissure. The Rolandic line lies entirely over the whole of the Rolandic fissure.

The method of Reid is founded on a base line which is drawn horizontally from the lowest margin of the bony orbit through the center of the external auditory meatus and then backward. A perpendicular line is drawn from

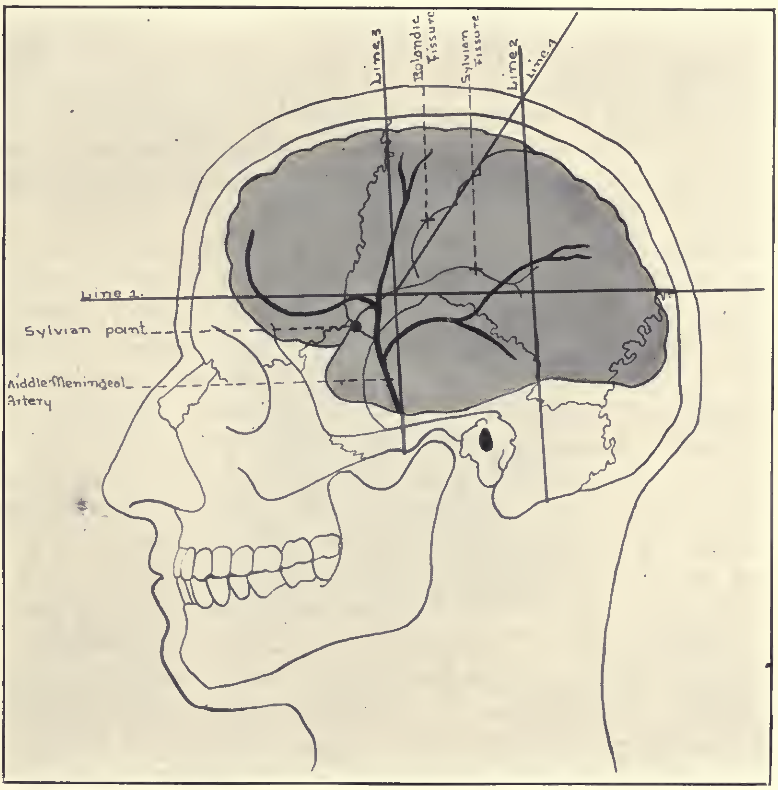

Fig. 300.—Method of Rinkenberger for cerebral localization.

just in front of the external auditory meatus at a right angle to the base line and ends at the median line above. A posterior perpendicular line begins at the base line at a point above the posterior margin of the mastoid process and goes vertically upward to the midline of the scalp. The Rolandic fissure is represented by a line beginning at the upper end of the posterior perpendicular line where it joins the anteroposterior midline of the scalp and passes diagonally downward and forward to a point where the Sylvian line crosses the anterior perpendicular line. The Sylvian line extends from one and one-quarter inches behind the external angular process to a point about three-fourths of an inch below the most prominent point on the parietal eminence.

F. W. Rinkenberger[1] describes a simplified method of cerebral localization, which is based on bony landmarks and needs no measurement (Fig. 300). It requires four lines, run from five landmarks: (1) a transverse line from the glabella to the lambda, or nasion to inion, (2) a perpendicular line from the posterior part of the mastoid to the sagittal suture, (3) a perpendicular from the tubercle of the zygoma to the sagittal suture, and (4) an oblique line connecting the junction of the zygoma and the glabella-lambda lines with the upper end of the mastoid sagittal suture line. This oblique line will practically cover the fissure of Rolando. The Sylvian point lies almost beneath the tip of the greater wing of the sphenoid where it joins the frontal and parietal bones. A perpendicular line up from the middle of the zygoma until it meets the glabella-lambda line will cover the Sylvian point at the junction with the latter line. If the glabella-lambda line is followed from this junction to the mastoid-sagittal suture line the fissure of Sylvius will be fairly accurately outlined. The line from the tubercle of the zygoma to the sagittal suture is almost over the anterior branch of the middle meningeal artery, the artery lying not more than one-fourth inch away at any point.

The location of the lesion of the brain having been determined and the osteoplastic flap made, the method of extraction of the tumor depends upon its shape, consistency and depth. If the growth is from the inner surface of the dura, or if it involves the dura, it will be necessary to remove this membrane. If the dura is not affected and the lesion is under the cortex it will often cause a protuberance which will indicate its location. The brain is usually under considerable tension. If the growth is not an infiltrating growth but is encapsulated, a small incision is made through the cortex of the brain to the growth and usually after a few minutes the growth is gradually extruded from the brain. It is highly important to handle the cortex of the brain with the greatest care. It should not be touched with dry sponges and it is preferable not to touch it at all. If manipulation of the cortex of the brain is necessary it is done gently with gauze wrung out of salt solution. If the tumor is not delivered in this manner, suction may be applied by taking the barrel of a glass syringe, removing the piston and connecting the nozzle of the syringe through a tube with another syringe, preferably a larger one. The base of the barrel of the syringe is placed over the region of the tumor and suction is made by the syringe that is connected with the nozzle of the glass cylinder barrel applied to the brain.

If bleeding occurs in the surface of the brain the vessels are ligated if possible with very fine silk in a fine curved needle. If this cannot be done a piece of muscle from the adjacent muscular tissue in the soft part of the flap is cut and crushed in a forceps and laid upon the bleeding spot. It is highly important to leave no bleeding surface on the brain or in the tissue that will come in contact with the brain.

If the dura must be excised, or if there are many adhesions between the cortex and the dura, which may be the whole cause of the trouble, a flap of

[1]Ann. Surg., Sept., 1918, pp. 351-352.

fat should be transplanted. The details of this will be described later. If the fat is more bulky than the dura a portion of the bone in the osteoplastic flap is removed in order to prevent too much compression upon the brain by the fat. The flap is replaced and the wound is closed, preferably without drainage, as drainage to the brain may be followed by infection or adhesions. The bone should be carefully replaced. If it seems to rest too heavily on the dura a small piece of fascia is interposed at intervals between the edges of the bone flap and the edges of the skull. The scalp wound is sutured as has already been described, taking care to close the galea accurately and to maintain accurate hemostasis by sutures. The galea can be united by a continuous suture of catgut and the skin by silk, horsehair, silkworm-gut or fine tanned catgut. Too much pressure should not be made over the region of the flap, as it may be transmitted to the brain.

Fig. 301.—"Cross bow" incision of Cushing for exposure of the cerebellum.

The method just outlined can be used with a few variations to uncover almost any region of the cerebrum, though the cerebellum requires a different type of incision. Here the "cross-bow" incision of Cushing gives good exposure (Fig. 301). After placing the patient with his face down, a curved incision is made a little above the superior curved lines of the occipital bone. A longitudinal incision goes downward from the middle of this curved incision onto the neck. The two triangular flaps of skin which are formed by the junction of this median incision with the curved incision, are dissected downward and outward until the insertion of the flat superficial cervical muscles is seen. Then these muscles are divided transversely about three-fourths of an inch below their insertion and a median vertical incision is made between the muscles down to the spinous process of the upper cervical vertebræ. The ligamentum nuchæ is split in the midline and the soft parts are retracted. The periosteum is elevated from the occiput and in this manner the attachment of the deep muscles of the neck is separated. The skull is opened through the

prominence of the occipital bone on each side of the midline with a burr and the opening is enlarged with rongeur forceps. The ridge of bone left in the midline is attacked last of all and must be removed with care because of the emissary veins. When sufficient bone has been removed the middle occipital sinus is ligated and the dura is incised. The wound is closed without drainage unless oozing is so extensive as to make it wise to insert a small piece of rubber tissue or rubber dam.

OPERATIONS FOR EPILEPSY

Operation for idiopathic epilepsy is but seldom if ever justified. When a cause is found for cerebral irritation it should be removed, but there should be at least a reasonable connection between the lesion and the epilepsy. It has been well known that any sudden shock or mental strain frequently results in the cessation of epileptic fits and this too frequently has been construed as therapeutically following the operation.

Undoubtedly care in treating fractures of the skull which will prevent unnecessary scar tissue in the injured brain, the dura or the scalp, tends to prevent epilepsy, but after epilepsy has been well established, even when there is a definite lesion of the brain, the removal of this lesion is by no means always curative. Such cases, however, are proper subjects for operation, but the ultimate results are not always gratifying.

Keen has laid much emphasis on the excision of the scar in the scalp, and if he finds no injury to the bone he removes the scar in the scalp, unites the wound carefully, and awaits the result of this operation. There are, however, many instances of injury to the brain that result in focal or Jacksonian epilepsy, in which the lesion can be definitely localized. It seems reasonable to suppose that if this is true similar lesions in silent areas in the brain may cause a general epilepsy without producing focal symptoms. Of course, in every such case a competent neurologist should be consulted and treatment directed to allay excitement and irritation to the brain should be instituted.

The object of operating upon the brain for epilepsy is to remove some lesion causing irritation. This in some instances may be a tumor or a cyst resulting from a previous injury that produced a localized clot or destruction of tissue. If a tumor or a cyst exists it is dealt with along the principles that have already been indicated for a brain operation. If the trouble is due to adhesions between the cortex of the brain and the dura, the problem becomes more complicated. If the cortex of the brain contains a scar, excision of this scar will probably give only temporary benefit. If the lesion is strictly focal and the whole center governing the convulsive portion of the body is removed, then, of course, permanent paralysis results and there is at least a possibility of the contraction of the resulting wound involving neighboring centers. This method of operation should be resorted to very guardedly, if at all, and only when the region of the brain involved is very small and the disease sharply outlined.

Adhesions between the cortex of the brain to the dura, or, if the dura is destroyed, to the structures overlying the brain, are responsible for many cases of focal epilepsy. Merely separating these adhesions and suturing the tissues does only temporary good. They will almost certainly re-form and the trauma of the operation may even add to their extent. The problem is somewhat different from that in the abdomen when the separation of adhesions is sometimes accompanied by removal of the cause of the adhesions, or at least by the opportunity to cover the two opposing raw surfaces with peritoneum. The mobility of the abdominal viscera also aids in the prevention of adhesions. The complicated tissues of the brain have poor regenerative powers and the cortical cells and their dendrites never regenerate. All of these things greatly favor not only the formation of scar tissue after any injury to the brain but the adhesions of the cortex of the brain to its overlying tissue.

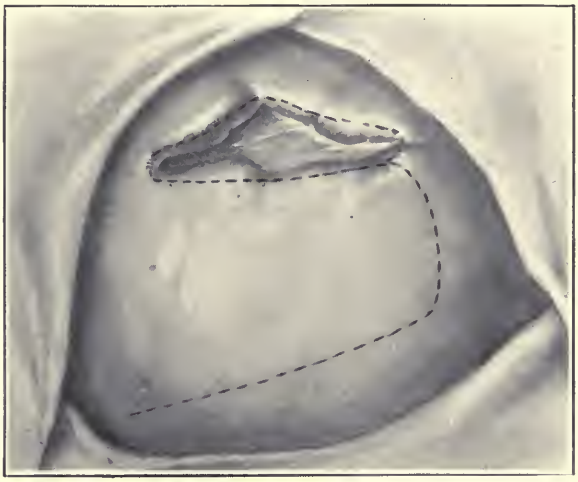

Fig. 302.—Lines of incision for operation for exposure of the dura and brain after an old depressed fracture.

The adhesions may be from the arachnoid or the piamater to the dura. Naturally the physiologic expansion and contraction of the brain makes such adhesions a source of considerable irritation and in individuals who are predisposed to convulsive seizures epilepsy may occur.

The methods of preventing adhesions of the cortex of the brain to the dura have been numerous. Most of them unfortunately have not been considered from a biologic viewpoint, but solely mechanically. It has apparently been conceived in some instances that if a piece of rubber tissue, or a strip of celluloid, or a gold or silver leaf would prevent two objects from touching each other, the same method would prevent adhesions of the brain to its overlying structures. As a rule, the interposition of foreign material between the cortex of the brain and the dura and its overlying tissues means not a prevention but an increase of adhesions. It may for a time be physically impossible for adhesions to penetrate the center of this foreign material and there are some foreign substances that are less irritating than others. The logical out-

come of these procedures, however, can easily be anticipated by anyone who has followed a small amount of experimental work in burying foreign substances in any portion of the body. If the foreign substance is absorbable and no infection occurs, it may be absorbed if not too large, and its place is usually taken by organized connective tissue. If it is nonabsorbable, as gold or silver leaf, rubber tissue or celluloid, nature tends to encapsulate the material and adhesions are formed around the edge of the foreign substance. The contraction of the adhesions not infrequently results in the crumpling up of the foreign substance until it may be broken into smaller pieces or rolled up in a

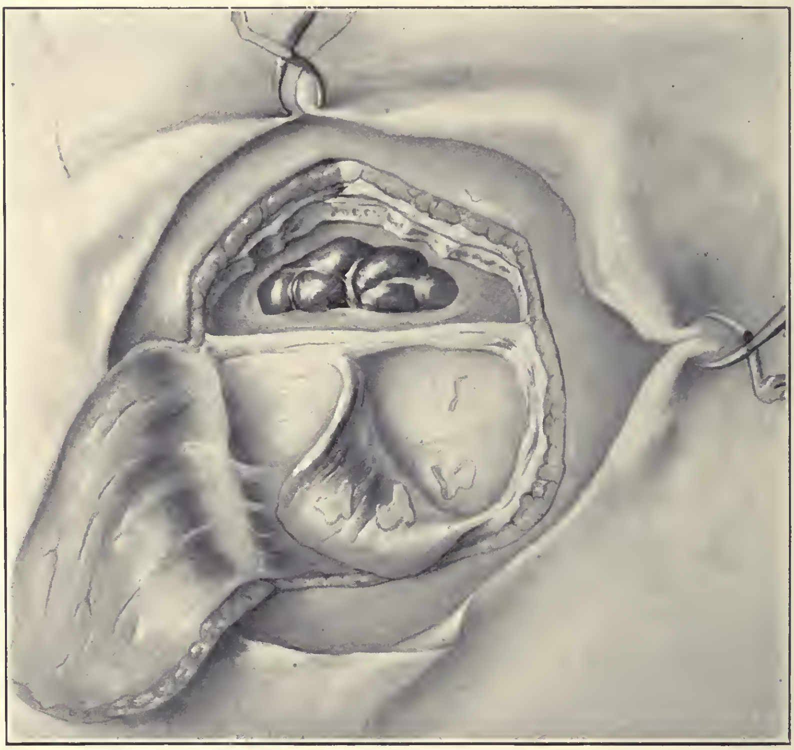

Fig. 303.—The adherent dura and tissues have been removed and the brain is exposed. A flap of scalp and a flap of pericranium with some bone attached are mobilized.

mass. Anyone who has seen a sponge or a piece of gauze accidently left in the abdominal cavity and removed weeks or months later can draw a very good mental picture of what happens in a smaller way when foreign substances are left on the cortex of the brain.

The transplantation of fascia or muscle over the denuded cortex is followed by adhesions. The only substance which seems to give satisfactory results that justify transplantation of tissue is fat, which has been employed successfully by Lexer, Dean Lewis, and others. This may be obtained either from the abdomen or from the thigh.

A satisfactory flap can be removed from the fascia of the thigh, taking

a coating of fat on the fascia lata and transplanting the fat and fascia to the brain, placing the fat next to the cortex. The fascia is united to the edges of the dura by a few catgut sutures. It is best to split the dura in several directions and to insinuate the edges of the fat under the edges of the dura. It is highly important in such cases to remove sufficient bone from the skull so that the replacement of an osteoplastic flap will not produce too much pressure upon the fatty transplant, which is normally much thicker than the dura (Figs. 302, 303, 304 and 305).

In performing such operations the lesion is usually indicated by the scar on the scalp and it is best so to shape the flaps of scalp as to enable the operator

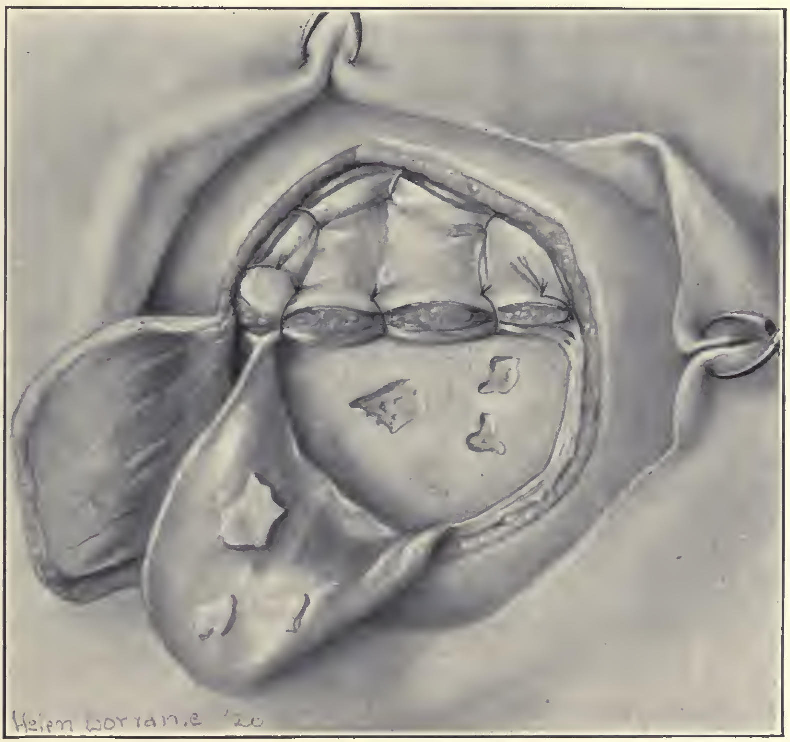

Fig. 304.—A fatty fascia flap from the thigh has been sutured over the defect in the dura.

to excise the scar in the scalp and to enter the skull on the margin of the supposed area of adhesion and not in its center. The skull immediately over these adhesions, if the area is not too extensive, should be removed entirely, so when the scalp is replaced there is no bone over the fatty flap to produce compression.

In three cases of epilepsy following trauma to the skull and brain I have used this method of transplanting a fatty fascia flap. Two of these patients have so far made a very satisfactory recovery. The third has been considerably benefited, but is not cured. It may be that the operation in this instance merely produced a temporary alleviation. In one of the two cases in which the result

was considered satisfactory the patient had been previously operated upon for general epilepsy elsewhere and a large osteoplastic flap had been turned down over the motor area. For several years he appeared to be relieved of his epilepsy, but later began having convulsive seizures of his left forearm and hand. These were not accompanied by unconsciousness. They would recur at intervals of fifteen minutes to half an hour. Operation showed marked adhesions of the piamater and arachnoid and of the cortex of the brain to the dura

Fig. 305.—The flap of pericranium is transferred over the fatty fascia graft.

over the arm and hand center. Elsewhere the cortex of the brain appeared to be normal and nonadherent. The adhesions were divided with a sharp knife and a fatty fascia transplant was made with the fat next to the surface of the brain. The arm and hand were paralyzed for several days and then weak motion began and finally the motion appeared about normal. When last heard from about two years after the operation, the patient had had no further convulsive seizures in his arm and hand and the motion had returned satisfactorily.

OPERATIONS FOR HYDROCEPHALUS

Many years ago, Hilton, in "Rest and Pain," stated that hydrocephalus was due to obstruction of the outlet of the cerebrospinal fluid from the brain. Recent research seems to emphasize Hilton's views.

The cerebrospinal fluid comes from the choroid plexus. About three-fourths of the choroid plexus lies in the two lateral ventricles, the third and fourth ventricles containing the remaining fourth. The cerebrospinal fluid makes its way through the aqueduct of Sylvius to the fourth ventricle, through the foramina of Luschka and Magendie to the subarachnoid space. Absorption of the cerebrospinal fluid is practically entirely from the subarachnoid space. The existence of fanciful stomata and the absorptive powers of the pacchionian bodies have been disproved. Normal absorption of cerebrospinal fluid takes place slowly by osmosis through the membrane of the subarachnoid space. The subdural space has but little absorptive capacity. The communication between the fluids of the ventricles and the subarachnoid spaces normally exists only through the fourth ventricle and the foramina of Luschka and Magendie. In the absence of these normal openings this communication can apparently be satisfactorily maintained only through openings made in this region.

Operations for hydrocephalus that are designed to cause absorption of the cerebrospinal fluid by transferring it to other portions of the body cannot in the nature of things be successful. The only benefit is the temporary reduction of pressure by removing the cerebrospinal fluid during the operation and the decompressive effect of removal of a portion of the skull. It is well known that forced absorption of fluid in tissues of the body as illustrated by a continuous hypodermoclysis of salt solution is temporary. The blockage of lymphatics in the region of the hypodermoclysis produces such a condition in the tissues that but little fluid is absorbed after a few days and that only under great pressure. If sufficient pressure existed within the ventricles of the brain to force the absorption of the cerebrospinal fluid after it has been conducted into the tissues of the neck, scalp or chest, the pressure itself would cause destruction of the brain. Operations for creating a channel between the ventricles of the brain and the sinuses of the dura sooner or later result in closure of the channel.

Hydrocephalus should be differentiated from acute inflammation of the brain in which there is an exudate from various tissues. This exudate ceases when the irritation of inflammation or trauma has subsided. For practical purposes it may be said that there is only one type of hydrocephalus, the obstructive form. The obstruction may exist along the aqueduct of Sylvius or in the roof of the fourth ventricle or in the subarachnoid space, which permits only a limited amount of absorption of cerebrospinal fluid, but is not a complete blockage as would be in obstruction of the aqueduct of Sylvius. In the form of obstructive hydrocephalus in which the obstruction is located at some distance from the fourth ventricle, the fluid communicates with this limited area of subarachnoid space and with the spinal cord.

It can readily be seen, then, that an operation which merely conducts the cerebrospinal fluid into tissues of the scalp or neck cannot succeed for reasons that have been mentioned. Operations such as puncture of the corpus callosum merely transfer the cerebrospinal fluid from the ventricles of the brain to the subdural space where almost no absorption takes place, the cerebrospinal fluid

being absorbed from the subarachnoid space. The problem, then, particularly in the communicating type of hydrocephalus, in which a small portion of the subarachnoid space near the fourth ventricle is still left but is shut off by adhesions from the larger subarachnoid space, consists in so reducing the formation of cerebrospinal fluid that the amount that is secreted can be absorbed.

Walter E. Dandy,[2] of Baltimore, has devised an operation for removal of that portion of the choroid plexus which lies in the lateral ventricles. It is impracticable to remove the choroid plexus from the third and fourth ventricles and, as three-fourths of the amount is in the lateral ventricles, the absorption of the cerebrospinal fluid formed from the twenty-five per cent of choroid plexus left in the third and fourth ventricles can probably be done by the limited amount of subarachnoid space remaining. Before attempting the operation, however, it should be determined that the hydrocephalus is of the communicating type, in which the obstruction is in the subarachnoid space. This is done by injection of one cubic centimeter of neutral phenolsulphonephthalein into either of the lateral ventricles of the brain. This solution is especially prepared and the drug that is ordinarily used to test kidney function is not satisfactory. If the hydrocephalus is of the communicating type a lumbar puncture done half an hour later will demonstrate the dye in the spinal fluid, but if the obstruction exists in the ventricular system the spinal fluid will remain colorless.

If the operation of Dandy is indicated, it is done as follows: A small circular bone flap is made over the parietal eminence with the base toward the midline and so located that it is well posterior to the Rolandic area. The flap of bone and then of dura is turned up, and the vessels in the cortex of the brain are tied with fine silk and the cortex of the brain is incised down to the ventricle. Into this incision is inserted a nasal dilating speculum, or if the ventricle is very large a spatula may be used. After removing all of the cerebrospinal fluid the choroid plexus is recognized as a brownish-red flocculent substance and is picked up with forceps at the foramen of Monro. The vessels are ligated with a silver clip, clamping a small piece of silver wire on the vessel with especially constructed forceps. A small pledget of moist cotton is inserted gently into the foramen of Monro to prevent blood from gaining access to the third ventricle. The choroid plexus is cut and gently stripped back to the floor of the body of the ventricle. When the glomus is reached, the choroid plexus is then picked up again at the tip of the descending horn of the ventricle and similarly stripped backward from this point to the glomus when the attachment to the glomus is liberated and the entire choroid plexus removed. Bleeding is slight but should be completely controlled by cotton pledgets soaked in salt solution. Great care must be taken to leave no bleeding points. The cavities that are left would cause collapse of the brain and are filled with salt solution. The opening in the cortex of the brain is

[2]Ann. Surg., Dec., 1918, pp. 569-580.

closed with interrupted sutures of fine silk in the piameter and arachnoid. The dura and scalp are closed with silk, taking care to have no leakage. A similar procedure is carried out on the other side at a different time.

Four cases operated upon in this manner by Dandy have all survived the immediate effects of the operation, though three died from two to four weeks after the operation. One was living and showed no evidence of return of the disease ten months after operation.

The operation is, of course, a severe one and should not be lightly undertaken but it is founded on scientific knowledge of the etiology and pathology of hydrocephalus.

Puncture of the corpus callosum may relieve temporarily the tension of the fluid in the ventricles of the brain and in instances in which this fluid is due to inflammation or trauma may be advisable, as has already been explained. It can hardly be curative in true hydrocephalus, because the fluid is drained into the subdural space instead of the subarachnoid and there is but little absorption in the subdural space. This operation is done preferably in the anterior third, or at least in the anterior two-thirds, of the corpus callosum, because the corpus is thinner at this portion. A small U-shaped flap of scalp is made with its base at the midline, or a straight incision can be used. The exposure of the skull is so located that the bone can be reached about half an inch from the midline and the same distance posterior to the coronary suture. The dura is opened, and a blunt malleable needle is passed downward and inward until it reaches the falx cerebri, which serves as a guide to the corpus callosum. The needle is then gently pressed through the corpus and fluid should immediately flow. The opening in the corpus callosum is enlarged by moving the needle forward and backward for about half an inch. The wound is closed in the usual manner without drainage. A probe may sometimes be used instead of a needle. Either instrument should have a scale marked upon it.

The lateral ventricle can also be punctured by the method advocated by Keen. Here a point is indicated about one inch behind and one inch above the external auditory meatus and in the posterior part of the first temporal convolution. After removing a small piece of skull and opening the dura the needle is directed inward and toward the top of the ear on the opposite side. The ventricle is about two inches from the surface of the brain.

OPERATIONS ON THE HYPOPHYSIS

Operations for removal of tumors of the hypophysis have been performed through the nasal route or through the region of the frontal bone. This latter has been developed into a standard operation and appears to be the method of choice.

The method that gives most satisfactory approach seems to be an attack by a frontal osteoplastic flap. This operation has been devised by McArthur. A flap is made with its pedicle in the temporal region. An incision outlining this flap goes from the midpoint between the eyebrows up the middle of the

forehead to the region of the normal hair-line. The incision is carried outward and a third incision is begun at the lower end of the frontal incision and goes outward along the upper part of the eyebrow to the outer margin of the orbit. Care is taken to keep the periosteum intact and as closely connected with the bone in the region of the flap as possible. The skull is perforated at the upper outer angle of the flap with a burr or a small trephine. The upper and middle portion of the bone flap is separated with a DeVilbiss forceps. The lower part of the vertical cut in the bone is deflected somewhat toward the base of the flap so as to avoid the frontal sinus. The lower horizontal cut in the bone ends just above the outer angle of the orbit, invading slightly the temporal fossa. The external angular process of the frontal bone is divided with a sharp chisel or a saw. The internal bony portion of the supraorbital arch is also divided, going through well into the orbital plate of the frontal bone. This ridge of the frontal bone is removed and kept in salt solution until the operator is ready to replace the flap. The bony roof of the orbit is then removed with rongeur forceps until the optic nerve is exposed. The dura is separated from the bone in its neighborhood. The anterior clinoid process is recognized. A transverse incision about an inch long is made in the dura between the clinoid processes about three-eighths of an inch above the level of the floor of the anterior fossa. Through this opening the optic nerve, the chiasm, and the pituitary tumor come into view. After removing the tumor or evacuating the fluid the frontal lobe is permitted to fall into place. The ridge of bone removed from the upper margin of the orbit is replaced and held in position by sutures. The osteoplastic flap is turned in position and fastened in the usual manner.

This operation has been modified and greatly improved by Adson and by Heuer. The osteoplastic flap is made by Adson with the base in the temporal region and the incisions placed much farther back, so the flap is largely in the hair region. The frontal sinus is thus avoided. The dura is incised freely as a flap and the brain, protected with strips of rubber tissue and moist cotton, is gently elevated with a broad spatula until the optic chiasm and the tumor are seen. The tumor is removed gently from within its capsule, if possible, leaving no bleeding points.

CONGENITAL HERNIAS OF THE BRAIN OR ITS MEMBRANES

There are occasionally found protrusions or hernias of the membranes of the brain or of the brain itself. They come through a congenital opening in the bones. If much of the brain is involved and the opening is large but little can be done except general compression, which must not be too great, with the hope that if this defect occurs in young children or infants the development of the growing child may remedy the defect. The prognosis is usually bad. When the sac consists solely of the membranes of the brain and contains fluid, and when there is no hydrocephalus or spina bifida, an attempt at radical cure may be made. If the opening in the bone is small there is considerable prospect of cure, though the operation must be carried out with care as to the details

and must be undertaken before the sac has ruptured, and, if possible, before the skin on the sac has become ulcerated. It is best to use local anesthesia.

Flaps with broad bases are dissected from the base of the meningeal sac. They should include healthy skin. The incision is made with a sharp knife and great care is taken to avoid opening the sac. Every bleeding point is caught with forceps. After reaching the bone the neck of the sac is cleared around

Fig. 306.—Photograph of baby with meningocele in the lower part of the occipital bone.

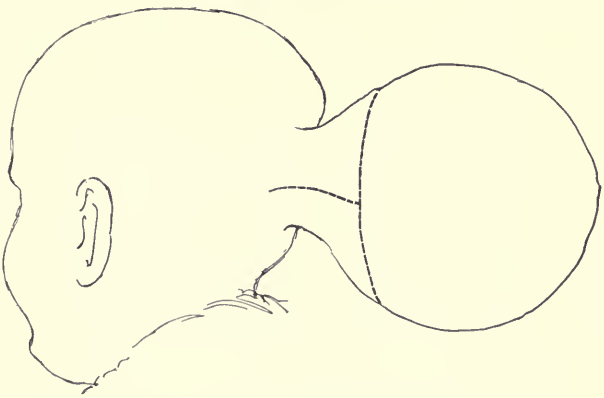

Fig. 307.—Lines of incision for excision of the meningocele shown in preceding figure.

the bony margin. If the neck of the sac is thin it should be very gently separated from the bony margin. If it is thick careful dissection with a sharp knife removes the excessive tissue and leaves the sac at its neck consisting almost entirely of the protruding dura. When the sac has been thoroughly freed from the margins of the opening in the bone and, if possible, from the bone for a short distance under the margin, a ligature of tanned catgut is tied around the sac as closely as possible to the normal surface of the brain. While tying this ligature no pressure is made upon the sac which would force an undue amount

of cerebrospinal fluid back onto the brain. After this ligature has been securely placed the sac is cut away. The stump of the sac is transfixed with catgut in a needle slightly distal to the ligature and whipped over and tied in order still further to secure the stump from leaking. A flap of pericranium is turned over

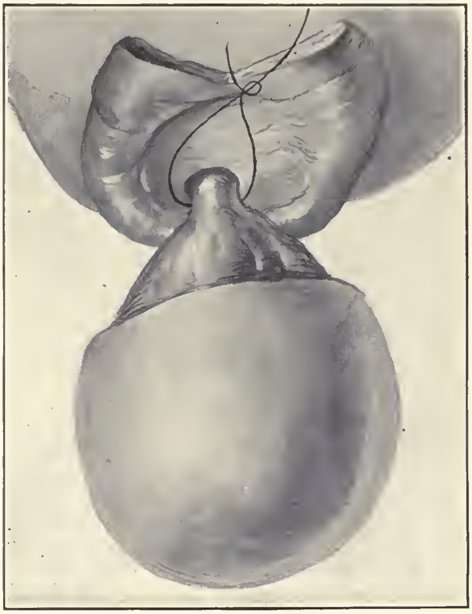

Fig. 308.—A cuff of scalp is turned back, the opening in the skull thoroughly exposed, and a ligature is placed around the neck of the sac.

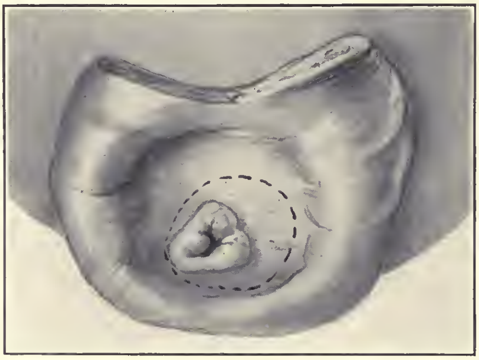

Fig. 309.—The neck of the sac is ligated. The lines show the incision for turning over a flap of pericranium.

the pedicle and sutured in position to the pericranium on the other side of the opening in the bone. The flap of scalp that has previously been formed should be abundant and is placed in position by suturing the galea or by everting two flaps of scalp and using a series of mattress sutures to give a lateral approximation to the galea. The skin is approximated with a continuous epithelial

stitch of fine silk. Whether one or two flaps of scalp are formed depends upon the condition of the scalp at the base of the meningocele (Figs. 306, 307, 308, 309 and 310).

In a baby three months old with the meningocele in the lower part of the occipital bone, I performed the operation just outlined and the baby made a

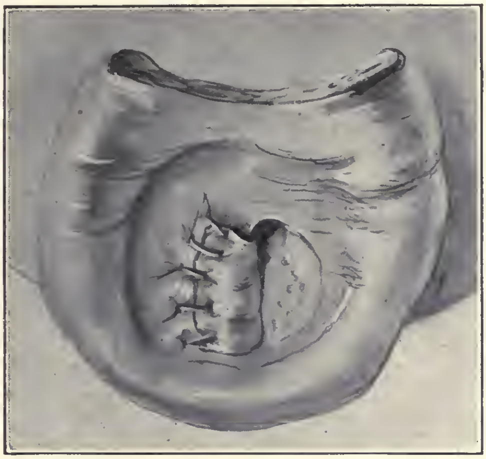

Fig. 310.—The flap of pericranium is sutured into position.

satisfactory recovery. When last heard from, about twenty months after the operation, the baby was improving and seemed to be developing mentally in a satisfactory manner.

DECOMPRESSION OPERATIONS

Operations for decompression of the brain have become popular since Harvey Cushing established the principle of performing this operation in the subtemporal region in such a manner that the fibers of the temporal muscle

Fig. 311.—Line of incision for subtemporal decompression. Where the decompression is to be more extensive, the incision may incline farther backward.

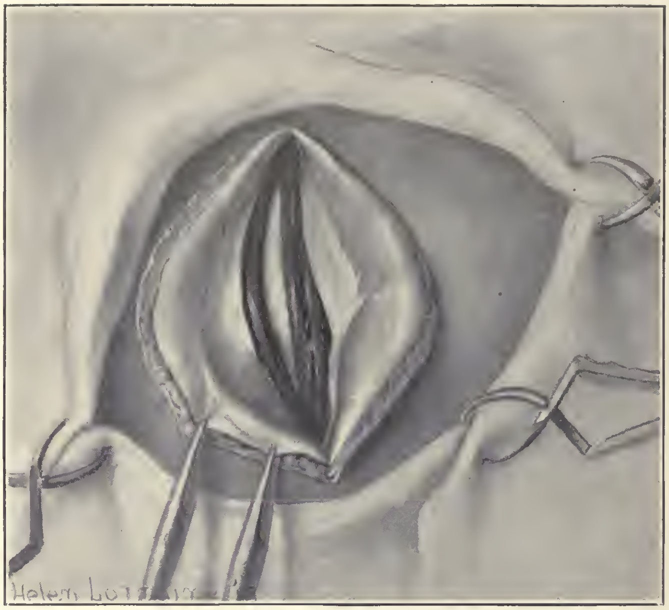

Fig. 312.—The fibers of the temporal muscle are separated and the pericranium and skull are exposed.

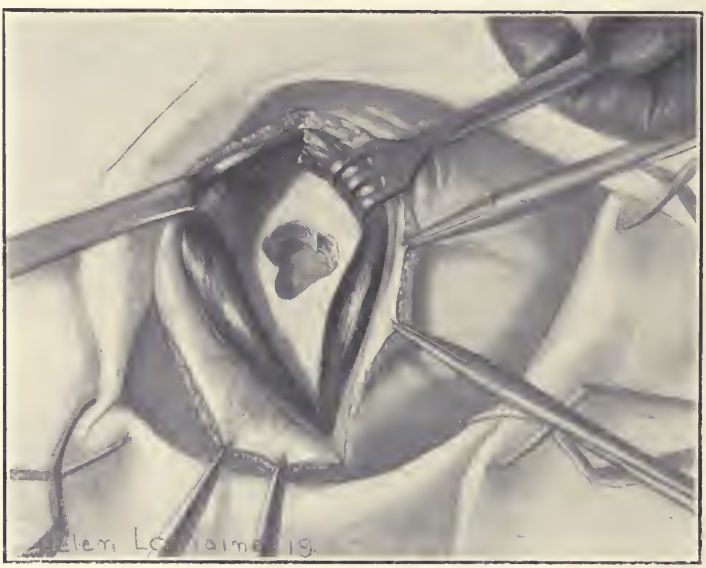

Fig. 313.—The skull is perforated with a drill or burr.

serve as a restraining influence to the protrusion and so prevent the enormous hernia that occurs when the decompression is made near the vault of the skull, where there is nothing to inhibit the protrusion of the brain except the skin and fascia of the scalp.

According to Cushing's original technic a curved incision is made about

one inch below the temporal ridge in the origin of the temporal muscle. This is entirely within the hairy portion of the scalp. A flap of skin and subcutaneous tissue alone is reflected downward, taking care to avoid injury to the

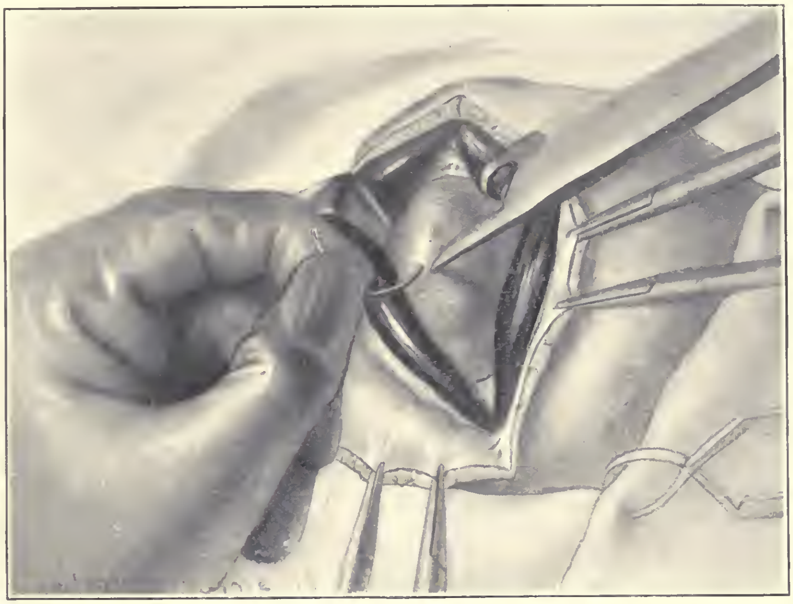

Fig. 314.—The dura is incised after picking it up with the point of a needle.

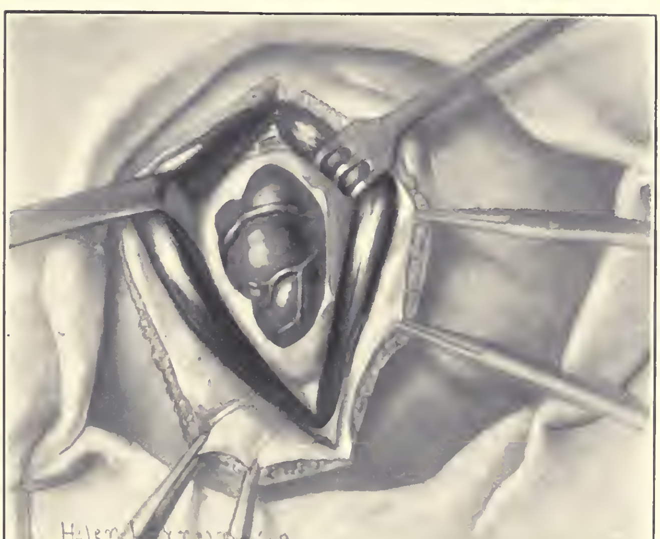

Fig. 315.—The dura has been split and the bulging brain is exposed.

temporal fascia. The temporal fascia is then split in the direction of its fibers where it runs downward and forward and the edges of the wound in the fascia are retracted while the temporal muscle is split between the bundles of its fibers.

Great care is taken not to cut across the muscle fibers of the temporal muscle, and also to preserve the origin of the temporal muscle. The pericranium is separated from the bone all around the region of the wound which is retracted to afford ample space (Fig. 312). The skull is perforated with a burr, the dura separated (Fig. 313), and as much of the skull as possible is removed from beneath the elevated soft parts, separating the dura well from the skull before removing each bite of bone. Any unusual bleeding of the bone may be controlled with bone wax. An opening is made which is carried well down to the region of the zygoma. An area of bone from two and one-half to three inches in diameter is removed (Fig. 314). A cross incision is made in the dura, which is split in radiating directions from the center of the wound. The incision in the dura should not be carried quite to the margin of the bone so as to

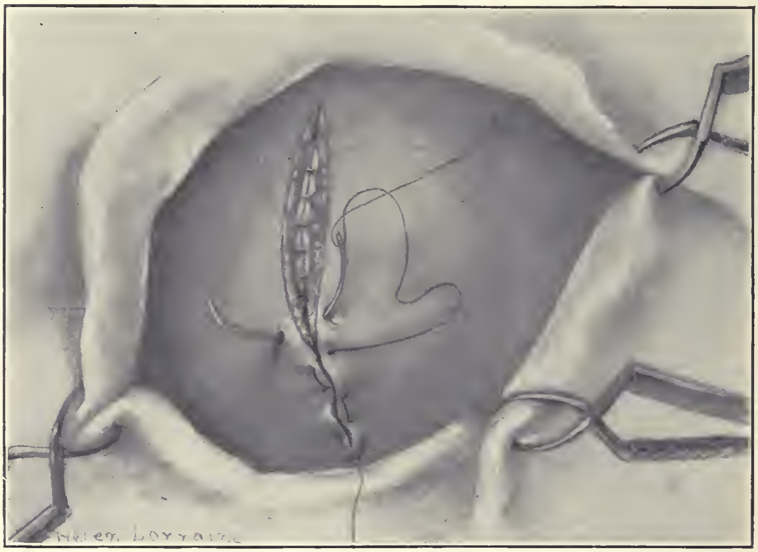

Fig. 316.—The wound is closed by suturing first the fibers of the temporal muscle, then the galea, and finally the skin. Closing the galea accurately is an important step in any operation on the scalp.

protect the brain from injury by the bone when it protrudes through the opening in the skull (Fig. 315). The branches of the meningeal artery may be tied in this operation. The muscle is brought together with a few interrupted catgut sutures and the temporal fascia is closed with continuous sutures of fine tanned catgut. The galea is sutured separately and the skin is closed in the usual manner for scalp operations (Fig. 316).

The advantages of this method of decompression are obvious, as it gives access to a region of the brain that is frequently the site of abscesses or tumors, it involves the silent area of the brain, and the support of the temporal muscle and fascia is obtained, which prevents undue protrusion of the brain, while permitting relief from excessive intracranial pressure.

The details of the decompression operation have been modified in the method of incision. Instead of using a curved incision, as Cushing recom-

mends, a straight incision may be made beginning about the middle of the zygoma and going upward and backward for about three and one-half inches (Figs. 311, 312, 313, 314, 315 and 316).

Sharpe recommends a vertical incision beginning just above the posterior portion of the zygoma and going upward three inches. This would seem to involve the regions that are nearer to the lower Rolandic area than the straight incision that is directed slightly backward.

An important step in the operation is to remove the bone in the thin temporal region of the skull as far toward the base of the skull as possible. The operation will not be satisfactory for tumors below the tentorium and here an occipital incision and decompression must be made according to the method already described for exposing the cerebellum. In patients who are right-handed, the speech center is supposed to be on the left side of the brain, so it is best to make the decompression on the right side unless there is some cerebral lesion or other reason for performing the operation on the left side. In left-handed patients the speech center is on the right side of the brain.

OPERATIONS ON THE GASSERIAN GANGLION

Instead of removing the gasserian ganglion when a radical operation for tic douloureux is indicated, it is best to do what is called a physiologic extirpation, and divide or avulse the posterior sensory root of the gasserian ganglion. This operation was first suggested by Spiller, of Philadelphia, and was performed by Charles H. Frazier, in 1901. The extirpation of the ganglion is not only a somewhat more difficult operation than division of its posterior sensory root, but is also more likely to be followed by trophic disturbance to the eye. This may be due to the fact that sympathetic nerves from the neck to the eye pass through the front and inner portions of the ganglion and are not disturbed by division of the posterior sensory root.

Frazier advises the sitting posture for this operation. If this cannot be done, the patient should at least be placed in the reversed Trendelenburg position. A skin flap, according to Frazier, is made with the hinge along the anterior hair-line. This is done by making a straight incision from a point over the upper border of the zygoma about its middle backward to the posterior extremity of the zygoma, then straight upward, then forward to the hair-line (Fig. 317). The flap of skin is turned forward and sutured to the towel surrounding the wound. A flap of fascia and muscle is formed which hinges backward and is sutured to the towel posteriorly. This latter flap does not go as far forward as the skin flap and the margin of muscle and fascia anteriorly is separated from the skull and sutured to the under surface of the skin flap. In this manner satisfactory exposure of the temporal bone is obtained without the use of retractors. The skull is perforated by a burr and the opening enlarged with rongeur forceps, taking care to extend the bony opening well down to the base of the skull (Fig. 318). An area of bone about one and one-quarter to one and one-half inches in diameter is removed. The dura is gently elevated from the middle

fossa of the skull until the foramen spinosum is approached. Here the middle meningeal artery is seen. The dura is elevated both in front and behind the artery and the artery is tied with silk or the foramen spinosum is plugged with

Fig. 317.—Lines showing the incision in the operation of Frazier for removal of the sensory root of the gasserian ganglion.

Fig. 318.—The flaps are reflected and the skull is perforated with a burr.

bone wax, a small piece of temporal muscle, or a small piece of gauze or cotton. If the artery cannot be tied, plugging the foramen spinosum will usually control it. The separation of the dura from the skull is then continued until the foramen ovale, containing the third division of the fifth nerve is seen. Any

bleeding points are controlled by pressure, pressing small pledgets of dental cotton over the bleeding spots and leaving them in position.

The third division of the fifth nerve is followed up to the posterior portion of the ganglion and an incision is made into the dura propria over the posterior part of the ganglion. This exposes the sensory root. The fibers of the posterior root are recognized and isolated, taking care to get the inner as well as the outer portion of the fibers. All of the fibers of the posterior sensory root are gathered with a small blunt hook and gentle traction is made which avulses the fibers from their origin (Fig. 319).

Adson[3] makes an incision in the form of a question mark, carrying the long end down in front of the ear. The incision begins one and a quarter

Fig. 319.—The sensory root of the ganglion is exposed and is about to be avulsed.

inches posterior to the external angle of the orbit and the same distance above the zygoma, and curves backward and then downward in front of the ear. Recently he has adopted a simple straight incision. He uses a special retractor with a small electric light at its end. The middle meningeal artery is always tied. This is done with a special aneurism needle after separating the dura in front of and behind the artery (Fig. 320). I have used a loop of silver wire for this purpose, the silk or linen ligature being placed in the loop after it has been passed around the artery. Adson does not uncover the ganglion but incises the dura propria behind the ganglion over about the middle of the posterior sensory root and demonstrates the dural opening through which this root goes to the brain. He advises cutting the fibers of the

[3]Surg., Gynec. & Obst., Oct., 1919, pp. 334-339.

posterior sensory root instead of avulsing them, and he does this with a special guillotine knife which is slipped over the fibers. He feels that division, which is all that is necessary, as these fibers do not regenerate, will inflict less injury on the medulla and nuclei in the neighborhood of the origin of the fifth

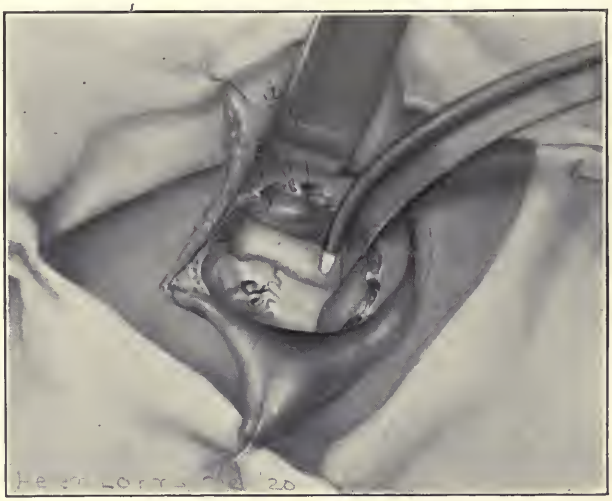

Fig. 320.—In the operation of Adson the middle meningeal artery is tied and divided. The sheath from the posterior sensory root is exposed and the brain held back with Adson's retractor.

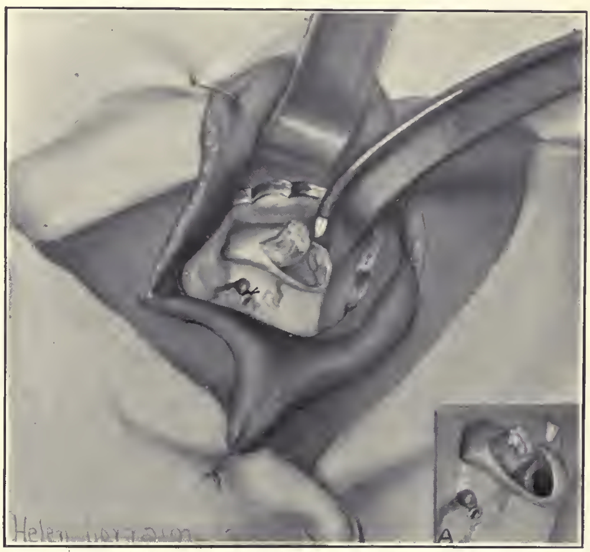

Fig. 321.—The posterior sensory root is divided in its sheath. Insert *A* shows the normal dural opening for the sensory root, the stump of this root having been shoved back into the dural cavity.

nerve, than will avulsion of these fibers. He has had a few cases of temporary facial paralysis following avulsion, but none following division. After division of the fibers the proximal stump is pushed back within the dural cavity and the opening in the dura is plugged with a small piece of temporal muscle,

which Adson believes lessens the leakage of cerebrospinal fluid (Fig. 321). The wound is closed in layers, using fine tanned catgut for the muscle and fascia and galea of the scalp, and fine silk or silkworm-gut for the skin. This is an excellent operation.

The patient leaves the bed after a few days. The eye over the affected side must be protected during convalescence either by an eye-shield or by frequent irrigation of the eyelid with a two per cent boric acid solution. If the eye is protected by a dressing it is important not to have the dressing press on the lids, for this in itself may cause injury to the cornea. Suturing the lids together for a few weeks is a very satisfactory method of protecting the cornea.

CHAPTER XVI

OPERATIONS ON THE SPINE

The operation on the spine that is most frequently performed is lumbar puncture. This may be done for diagnostic purposes, for treatment either in removing excessive fluid or injecting remedies, or for the administration of spinal anesthesia. The operation, while comparatively simple, is by no means devoid of danger, and should not be approached without the proper equipment of instruments and a correct knowledge of the operation.

The needle used by Frazier has a short bevel so there will be a minimum amount of injury to the nervous structures and so the dura can be penetrated with but little chance of having part of the opening of the needle within the dural cavity and part without. A needle with a long, slender sloping bevel may cause some of the injected fluid to leak outside the dura, even though some of it may reach the dural cavity. It is best to have the needle of platinum, though this is not essential. The diameter of the lumen of the needle is about one millimeter. The other instruments depend upon what is expected to be accomplished by the lumbar puncture. If it is for diagnostic purposes a three-way stop-cock attached to the needle or incorporated in the needle facilitates the measurement of the pressure of the cerebrospinal fluid. A manometer, preferably the Landon mercurial manometer, should be ready. In addition there should be two test tubes, two small graduates and a hypodermic syringe, as well as the connecting tubes between the manometer and the spinal needle. When the instruments have been properly sterilized and the lower portion of the lumbar spine has been painted with tincture of iodine, the tip of the spinous process of the fourth lumbar vertebra is found by stretching a sterile towel from the tip of the crest of one ileum to the tip of the crest of the other. This line marks the spinous process of the fourth lumbar vertebra and the best point for puncture is immediately below this.

The operation should be performed with gloves and with the same aseptic care that would attend any surgical operation. The skin may be infiltrated with one-half of one per cent novocain solution and a short incision made with the point of a tenotome or a Hagedorn surgical needle. This makes it easier to insert the spinal needle which has a short bevel, and at the same time decreases the possibility of the needle carrying into the spinal cord germs from the deeper layers of the skin. The patient bends forward as far as possible. The needle is inserted in the midline, half-way between the spinous process of the fourth and that of the fifth lumbar vertebra. If the patient is suspected of having a brain tumor the puncture should always be done in the horizontal position, which is the safest under any circumstances. The needle is pushed

straight inward and slightly upward almost perpendicular to the plane of the skin, though with a slight tendency upward. As it passes through the ligaments of the spine considerable resistance is felt. When it reaches the dura the sensation is often obtained as though the needle were puncturing parchment. Here it should be shoved forward very gently and the stylet withdrawn.

If the needle is graduated, some help is afforded in estimating the distance of the point of the needle from the dura of the spine, though the depth of the dura is rather variable. In infants and children, the distance from the skin to the dura is about one inch. In thin frail individuals it will vary from one and three-quarters to two and one-half inches. In muscular patients it will be about two and one-half to three and one-half inches, whereas in very stout persons it may be half an inch deeper.

No advantage can come from inserting the needle to the side of the midline, as is advocated by some authorities. First of all, it is impossible to tell the exact depth of the dura from the skin and therefore the needle cannot be entered accurately except in the posterior midline of the dura. On either side of the midline it is likely to encounter more bleeding vessels than it would in the midline, and in addition there is greater possibility of injuring the fixed portions of the spinal roots that are emerging from the dura.

After the stylet has been removed the further procedure will depend upon the indications for lumbar puncture. If for diagnostic purposes, the first thing to be determined is the pressure of the cerebrospinal fluid. The mecurial manometer of Landon, as used in Frazier's clinic, is probably the most satisfactory instrument for this purpose.

What is the normal pressure of the cerebrospinal fluid is a subject that evokes much discussion. The pressure fluctuates under normal and abnormal conditions. Slight variations are caused by inspiration and expiration, by the blood pressure, by the position of the patient, and by coughing or forced muscular movement. While Frazier has found that a transitory fall in the pressure of the cerebrospinal fluid is caused by closure of the carotids, obstruction of the venous circulation causes a rise in pressure. Variations from 72 millimeters of water to 200 millimeters of water are given as extremes of normal of the cerebrospinal fluid by different authorities. With the mercurial manometer of Landon anything over twelve millimeters of mercury is regarded as suspicious and twenty millimeters as distinctly pathologic. Frazier[1] regards the normal pressure with the patient quiet and on the side as about 8 millimeters of mercury.

After the pressure has been obtained the stop-cock can be switched to the sterile graduate, and enough fluid collected for examination. For an ordinary examination, Wassermann, cell count, albumin, sugar, and bacterial cultures, 5 c.c. are sufficient. This should be slowly withdrawn. If the fluid is under great pressure and the object of the lumbar puncture is to decrease this pressure, more fluid is withdrawn and the measurement of the pressure occa-

[1]Frazier, C. H.: Surgery of the Spine and Spinal Cord, New York, 1918, D. Appleton & Co., p. 151.

sionally taken to indicate when the withdrawal should cease. If the flow is too rapid it is checked at intervals. If it is intended to give spinal anesthesia, the amount withdrawn should be equivalent to the volume of the anesthetic mixture to be injected. Many operators prefer to withdraw a definite amount of the cerebrospinal fluid and dissolve the previously sterilized anesthetic tablet in the withdrawn cerebrospinal fluid. This, of course, adds to the specific gravity of the reinjected fluid and this objection has been overcome by Daniel A. Orth,[2] by dissolving the anesthetic in a sufficient amount of distilled water to make the solution have the same specific gravity as the cerebrospinal fluid. The amount of cerebrospinal fluid equivalent to the volume of the anesthetic solution is withdrawn permanently and then a small amount of cerebrospinal fluid is withdrawn, mixed with the anesthetic solution, and reinjected into the spinal canal.

LAMINECTOMY

The operation by which tumors or other lesions of the spinal cord are approached is laminectomy, which consists in the removal of the spinous processes and the laminæ of the vertebræ. The location of the lesion in the spinal cord should, of course, be very accurately ascertained. If the lesion is supposed to be a tumor, it is likely to be higher in the canal than anticipated. After marking the vertebra which lies immediately over the lesion, its spinous process is indicated by touching the skin over it with nitrate of silver. This is done the day before the operation. The incision through the skin is crescentic, beginning in the midline a vertebra above the highest vertebra that is to be removed, curving outward and returning to a vertebra below the lowest vertebra to be removed (Fig. 322). This flap, including fat and superficial fascia, is reflected to give ample exposure to the spine. The margins of the flap are covered with gauze wrung out of salt solution and an incision is made in the intervertebral fascia, which begins in the midline at the tip of the spinous process just above the first one to be removed and follows closely the sides of those spinous processes to be removed, terminating in the midline just below the last spinous process. These incisions are made first on one side of the spine and then on the other, hugging the bone quite closely. The muscle is separated from the spinous processes and the laminæ by a broad chisel which hugs the bone as closely as possible and in this way not only prevents bleeding, but, by stripping up some periosteum and fragments of bone, leaves tissue from which later on bony elements of the spine are sometimes regenerated. All of the periosteum cannot be removed, though some of it with small chips of bone can be separated by the chisel. The bleeding is greatly lessened by keeping close to the bone and when too free is controlled by packing the wound with gauze and placing retractors over the gauze in a manner not only to expose the spine but to use pressure on the bleeding surface. Any large spurting point is

[2]Surgical Clinics of Chicago, Feb., 1919, pp. 201-213.

controlled by whipping it over with catgut. Self-retaining retractors may be used but the ordinary hand retractor is usually satisfactory.

The interspinous ligaments are separated with a knife both above and below the spinous process, several of which are removed with bone forceps. The laminæ are removed with rongeur forceps (Fig. 323). In the lower part of the spine, in the lumbar region, it is sometimes difficult to

Fig. 322.—The incision for laminectomy according to Frazier.

find an opening. Here, if a small rongeur forceps cannot be insinuated under a lamina, an opening may be made with a burr as in the skull and enlarged with a DeVilbiss forceps until sufficient bone has been removed to enable the rongeur forceps to be used. Care is taken not to injure the dura and the cord during these manipulations. Before the dura is opened all bleeding points are stopped. Those in the bone can be controlled by the application of bone wax. At other points either pressure or whipping over with catgut

will suffice. Before opening the dura the wound should be completely covered with fresh gauze wrung out of salt solution. The dura is carefully inspected for irregularity of contour or color before it is opened. It is caught up with the point of a small curved needle held in hemostatic forceps and incised, or, as practiced by Frazier, two small black silk sutures are inserted on each side of the midline and the incision is made between them. These su-

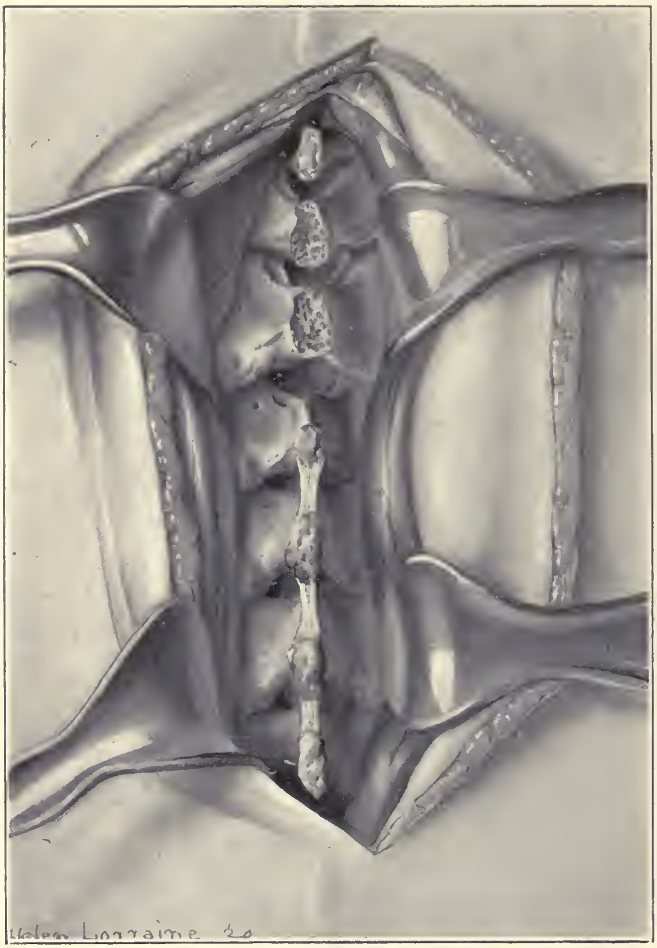

Fig. 323.—Spinous processes have been partly removed.

tures should not perforate the dura. The incision is carried down through the dura with the intention of not cutting the arachnoid (Fig. 324). If the arachnoid is not wounded it bulges into the wound like a fetal membrane before the waters have broken. A groove director is inserted and the dura is further opened both upward and downward from this midpoint. Two more sets of small silk sutures are inserted at the distal ends of the incision in the dura and are clamped by hemostatic forceps at a sufficient distance from the

wound not to be in the way. A small cylinder of cotton about one-third of an inch in diameter is placed on each side of the incised dura at the depth of the wound to catch any blood that may accumulate. When this cotton roll becomes saturated with blood it is replaced by a fresh one (Fig. 325). It is highly

Fig. 324.—The dura of the cord is incised.

important throughout the operation to protect the cord and the cavities containing the cerebrospinal fluid from blood. Pulsation or absence of pulsation and the amount of tension of the cerebrospinal fluid is observed before the arachnoid is opened as well as before incising the dura. The arachnoid space is opened and cerebrospinal fluid permitted to escape. The cord should

be handled with the greatest gentleness. The position of the patient should be such that the wound is approximately at the highest point and the patient should be well under the anesthetic so that no attempt at coughing or vomiting will cause an undue loss of cerebrospinal fluid. The cord should not be sponged with a dry sponge and should be manipulated with the greatest delicacy throughout.

If a tumor is to be removed and it does not present readily into the wound, the cord is gently manipulated by using traction upon the dura on the side to be exposed. The cord or its roots should never be grasped until definitely assured that this is necessary. If a tumor presents under the dura and is adherent

Fig. 325.—The dura has been incised and the cord is exposed.

to the dura, a portion of this membrane may be removed along with the growth. If the tumor is within the substance of the spinal cord its removal is a matter of the greatest delicacy. An incision is made over the tumor as near the midline of the cord as possible and with a very sharp thin knife. Often, after waiting a few minutes, the tumor gradually extrudes itself. Some operators advise closing the muscle, fascia and skin, and doing a second operation a few weeks later, claiming that nature can extrude the cord in this way with less injury than the operator will inflict. If, however, the tumor can be gently raised with a minimum of trauma it may be removed at this time. If bleeding is caused by the efforts at removal, these efforts should cease at once and the operation is left for another stage or else entirely abandoned.

If the object of the laminectomy is to section the posterior nerve roots for the relief of pain, or to relieve spastic conditions, the nerve roots that are intended to be removed are identified and divided with a sharp scissors. Not infrequently a small vessel may be encountered and this is best controlled by ligating the roots with very fine silk and dividing the root between the ligatures. If the silk is exceedingly fine it will cut through the soft structure of the nerve and hold only the blood vessels. This, of course, cannot be done in the peripheral nerves, as the surrounding fascia and sheath of the nerve protect the fibers and prevent them from being cut through with the ligature.

It must be recognized that the spinal cord, particularly that part exposed posteriorly, consists largely of very sensitive sensory fibers, and unless carefully manipulated not only is injury done to the cord but shock is produced. The cortex of the brain while made of delicate structures has but little if any sensation, and when manipulated shows but little shock. This, however, is not true of the spinal cord. Frazier suggests what he calls the stovain block in which he applies small pledgets of cotton soaked in one cubic centimeter of four per cent stovain solution at the upper portion of the exposed cord, tucking it snugly between the cord and the dura.

Fig. 326.—The dura is sutured.

After accomplishing the desired manipulation for the lesion for which the operation is done, the pledgets of cotton are removed and every bleeding point about the dura or arachnoid is controlled. The dura is sutured with a continuous suture of fine tanned catgut or fine silk (Fig. 326). Interrupted

sutures of stout silkworm-gut are placed well beyond the margins of the skin wound through the fascia and deep muscles of the back but are not tied. The muscles of the back are approximated with a continuous suture of tanned catgut and the fascia with a continuous lock stitch of tanned catgut. The skin is closed with a continuous suture of fine tanned catgut or fine silk. The interrupted sutures of silkworm-gut are tied over a roll of gauze to prevent cutting the skin. No provision is made for drainage. A flat sterile cotton pad is placed on the bed opposite the wound and the patient is returned to bed without any unusual restrictions.

Osteoplastic methods of laminectomy are not satisfactory and the function of the spine after laminectomy done in the manner described is good.

SPINA BIFIDA

Operations for spina bifida should not be undertaken without a knowledge of the pathology of the disease and the different types of the defect. A bifid spine is, of course, a congenital defect and may vary from a simple hernia of the meninges of the spinal cord to the protrusion of practically all of the elements of the cord through an extensive defect in the posterior portion of the spinal canal. The different types of spina bifida may be classed as: (1) meningocele, in which the meninges and chiefly the dura of the spinal cord constitute the protrusion; (2) myelocele, in which there is grave involvement of the spinal cord and which is probably the most serious form of spina bifida; (3) myelocystocele, or syringomyelocele, in which fluid accumulates within the substance of the cord itself; and, (4) spina bifida occulta, in which there has been a defect in the spine but no protrusion.

The simple meningocele offers the best prospect for successful treatment by operation. In this variety of spina bifida there is a defect in the posterior portion of the vertebræ, or sometimes in the vertebræ and dura, in which the other membranes of the cord protrude if the dura is absent. This form, which is the most favorable for operation, is not the most common variety. It is frequently found in the sacral region, sometimes in the cervical, and occasionally in the lumbar or thoracic portion of the spine. The sac may be composed of dura alone, or of dura and arachnoid, or only of arachnoid. Usually the dura is present. Sometimes in the lower portion of the spine the cauda equina is adherent to the sac wall, though it is usually free. The skin covering of the meningocele type of spina bifida is frequently normal or at any rate is not often ulcerated, though toward the summit of the protrusion the skin is sometimes very thin. Not infrequently a tumor, as a fibroid or dermoid cyst, rests upon the meningocele. Any fatty or fibroid tumor that arises in the midline of the back should always be suspected of being connected with a spina bifida.

The second form, myelocele or meningomyelocele, is the most hopeless type of this disease, because the spinal cord and its membranes and the skin are all involved. The arrest of development of this type of spina bifida oc-

curs very early in fetal life and the posterior wall of the neural tube and the adjoining membranes do not close, so there is a direct communication with the central canal of the cord. The fluid collects in front of the cord and consequently pushes the cord backward. The sac is composed of pia and the flattened cord, or the cauda equina and nerve roots. The nerve roots become elongated from the pressure backward of the cord. This type of spina bifida always has a characteristic covering. About the center of the protrusion is what is known as the medullo-vasculosa area, which is occupied by granulations. This is oval in shape and here even the pia is lacking. This portion of the sac is formed of the ventral surface of the central canal of the cord. Along the middle is usually a groove which shows where the cord is attached. Just without this central or medullary zone is the serous zone or epithelio-serosa zone. This is pink and very thin and does not contain any of the corium of the skin. External to this and surrounding the outer part of the growth is what is known as the dermic zone, composed of slightly thickened skin.

In the third type, myelocystocele, or syringomyelocele, there is a defect in the posterior part of the spinal column and dura, but the arachnoid, pia and epidermis have closed. The skin is usually about normal. The fluid is in the central canal of the cord, which is greatly dilated. The cord is compressed so that portions of it may have disappeared and the nerve roots are greatly stretched. Naturally, this tumor, as a rule, has a broad base, is soft and not so tense and prominent as the two other forms that have been described. The skin is often thick. From the great involvement of the cord in this and in the preceding type, there usually is paralysis or club foot or some evidence of injury to the spinal cord.

In the fourth type of spina bifida, spina bifida occulta, there are symptoms that only occur from tension upon the cord. This is the result of an early form of a small meningocele type and the connection between the skin and the membrane around the cord still holds, though the sac has disappeared. As the patient grows, this connection does not grow as rapidly as the other portions of the body, so tension is made by this band upon the structures of the cord, and permanent injury to the cord may occur on account of this traction.

Whether a patient suffering with spina bifida should be operated upon for this defect depends upon the general condition of the patient and upon the type of spina bifida present. Even in the meningocele types, which are most susceptible to operation, if there is an accompanying marked hydrocephalus, operation should not be done. While it is undoubtedly true that the prime defect in bifid spine is lack of development of the posterior portions of the spinal vertebræ, it is probable that some other pathologic influence must be present during development such as increased pressure of the cerebrospinal fluid. If hydrocephalus is also present and the sac of the meningocele is removed there is no safety valve left to take up any unusual increase in the pressure caused by the hydrocephalus.

As Frazier has remarked, it by no means necessarily follows that when a hydrocephalus develops after an operation for spina bifida the relation is one of cause and effect, because hydrocephalus has devloped in infants with spina bifida who have not been operated upon. It seems good surgical judgment, however, not to operate upon any case of spina bifida with marked hydrocephalus, paralysis of the sphincters, or of both lower extremities. It is best not to operate upon these patients until after they have attained the

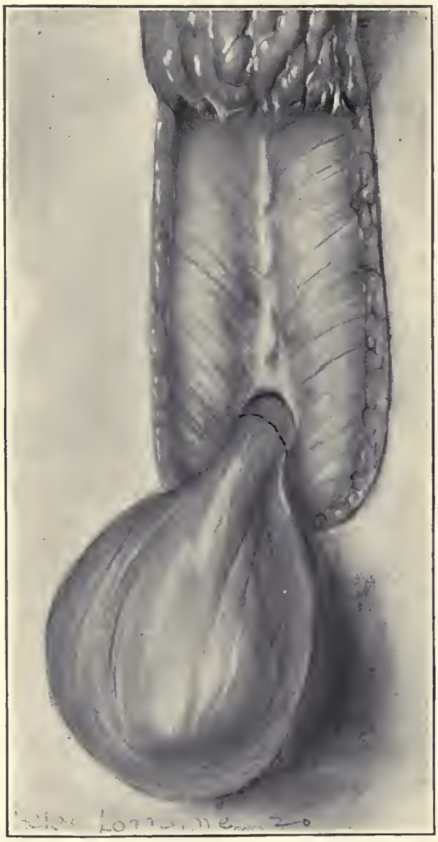

Fig. 327.—The sac of a spina bifida has been exposed by a U-shaped flap. The dotted lines show lines of incision in the sac. (Frazier.)

age of one year, at least, unless there is a threatened rupture of the sac of the meningocele type.

In spina bifida occulta, operation should be done as soon as symptoms appear. Here the indication is for a limited laminectomy and division of the cord or band that is causing trouble.

In the second and third types, myelocele and myelocystocele, but little hope can be entertained for operation of any kind as the involvement of the cord has been so extensive that the damage to the spinal cord from pressure

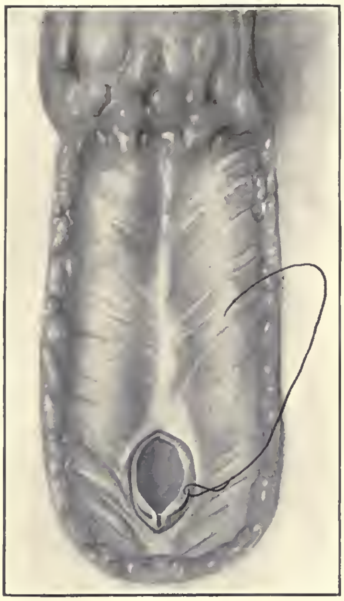

Fig. 328.—The stump of the sac is being sutured. (Frazier.)

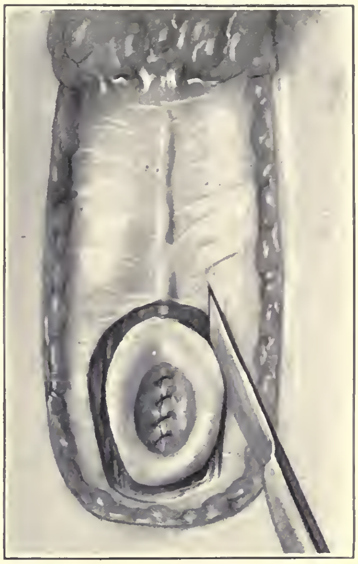

Fig. 329.—A fascia flap is formed to turn onto the stump of the sac. (Frazier.)

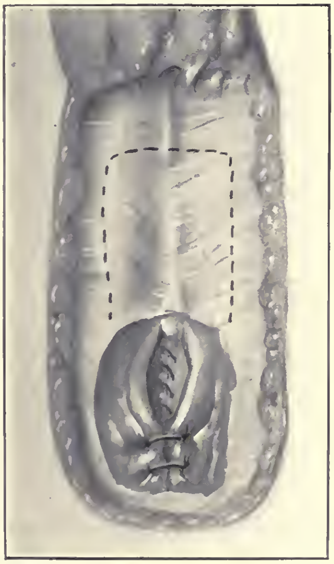

Fig. 330.—The lines of incision for a flap of fascia to still further cover in the defect. (Frazier.)

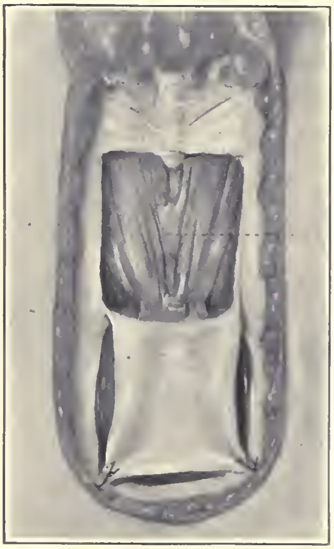

Fig. 331.—The flap of fascia outlined in the preceding figure has been turned down and is being sutured in place. (Frazier.)

and distortion must have already occurred. Most of these cases die early, within the first year.

If operation is to be done the technic should be selected according to the type of spina bifida. If the growth is a simple meningocele with a narrow base it may be operated upon by an incision a little to one side of the center

of the growth, or by the U-shaped flap, which Frazier prefers (Fig. 327). After exposing the sac it is cut away. The incision is made carefully in order to be certain that no elements of the cord are contained in the sac. The margins of the sac are whipped over with a continuous suture of fine silk or fine tanned catgut (Fig. 328). An incision in the fascia just external to the margins of the defect will turn a flap on to the sutured neck of the sac (Fig. 329). The muscles on each side are approximated and, following Frazier's technic, a flap of fascia is turned down with its hinge along the upper margin of the defect and sutured to the edges of the fascia, so covering the sutured muscles (Figs. 330 and 331). This flap of fascia may be a free transplant from the fascia lata. If the growth is a larger

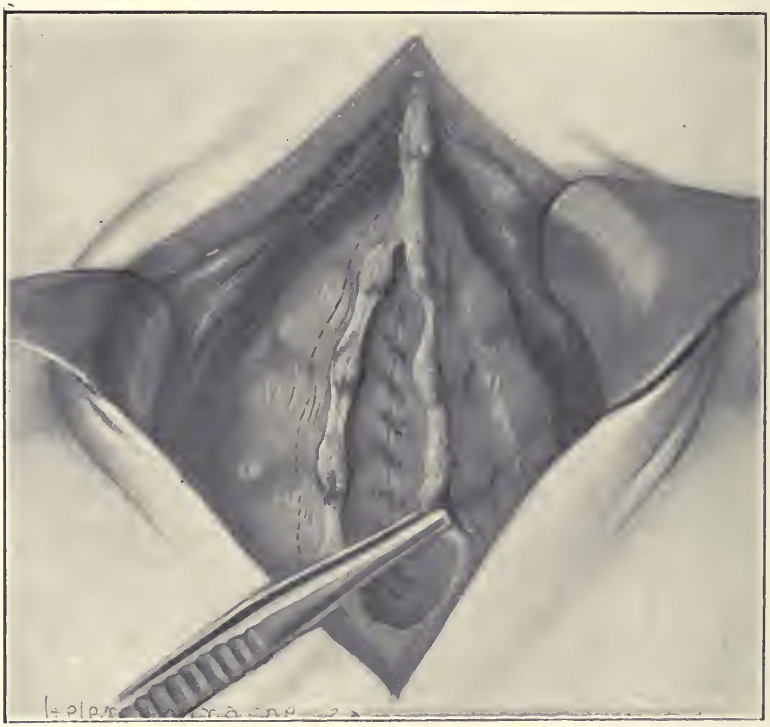

Fig. 332.—Operation of Babcock showing the division of the stumps of the laminæ on the right side and the proposed line of division on the left.

one or if elements of the cord are contained in it, an effort should be made to locate the elements of the spinal cord by gentle palpation or by transillumination before opening the sac.

In myelocystocele or myelomeningocele, if operation is considered, the difficulties of dealing with the sac will be great.

Where a number of vertebræ are involved an osteoplastic operation may be indicated. Babcock, in 1910, elaborated a technic for this type of spina bifida. After freeing the sac, excising it and suturing its stump, the margins of the bony canal are freely exposed and the stumps of the laminæ on each side are

fractured by a Satterlee bone forceps. In this manner two flaps are formed consisting of bone and fibrous tissue, each of which is attached above and below (Fig. 332). They are sutured together in the midline with tanned or chromic catgut. Relaxation incisions are made in the muscle and aponeurosis on each side of the spine to permit the muscle and its aponeurosis to be sutured together in the midline (Fig. 333). The skin is brought together with great care, as it is often thin and poorly nourished. Mattress sutures tied just tightly enough to approximate the skin are satisfactory in closing the skin wound in this operation (Fig. 334).

Fig. 333.—The deep layers of tissue containing the laminæ have been united and the fascia over this is brought together after making relaxation incisions.

If it is impossible to bridge the defect satisfactorily by either of the two types of operation mentioned, then bone grafting, using the method of Albee, may be considered. This may be necessary in wide defects in the lower lumbar region. Here Albee in order to immobilize the spine transplants two bone grafts which meet at an apex in the lumbar vertebra immediately above the deformity and separate, forming a triangle, with the other ends of the grafts at each side of the base of the sacrum. The technic is quite similar to that used in bone grafts for Pott's disease of the spine, except that the rudimentary

spinous processes cannot be split. When this is impossible the spinous process is denuded and the bone graft fastened to the rudimentary spine.

A meningocele that is sometimes exceedingly puzzling is the kind in which the defect in the spinal column occurs in the body of the vertebra and not in the lamina. In such an instance the pelvis may be lifted with a cyst that resembles in physical characteristics an adherent ovarian tumor. If there is marked pain, or particularly if there are nervous symptoms in the lower extremities, the possibility of such an unusual spina bifida should be borne in mind. If the defect is not large, treatment could probably be carried out by

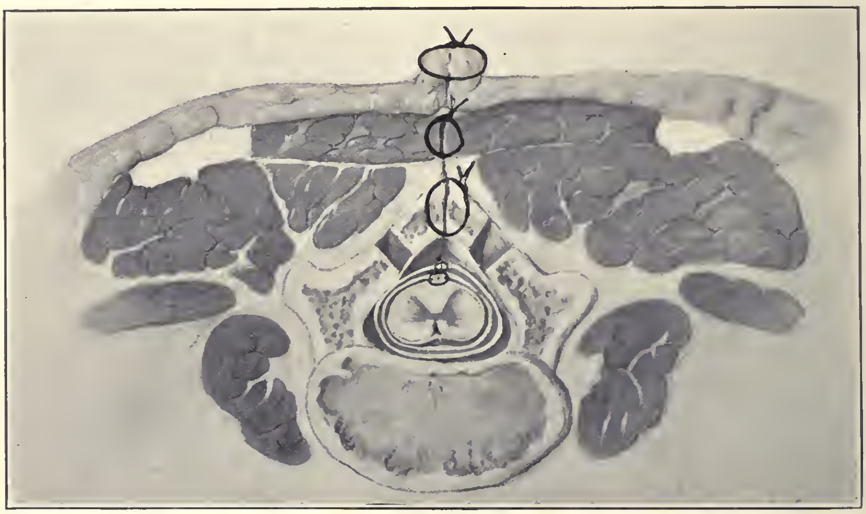

Fig. 334.—Section showing the various layers of tissues that are sutured in the operation of Babcock for spina bifida.

excision of the sac and ligation of its neck, together with transplantation of fascia, or such other plastic procedures as might appear to be indicated in the particular case.

During any operation for spina bifida the patient should be so placed that the spina bifida is the highest point, so there will be but little tendency for the cerebrospinal fluid to escape during the operation. It is wise to lay these patients on the abdomen after operations and not on the back, as in infants or very young children there is a great tendency for the wound to be infected by urine or the bowel movements.

CHAPTER XVII

OPERATIONS ON THE NECK

Some operations on the neck have already been described under the head of surgery of the blood vessels or surgery of the nerves and will be found in the preceding chapters.

Operations on the neck should not be undertaken unless the operator has a thorough practical knowledge of the anatomy of the neck. It is entirely possible for one with but little knowledge of anatomy to do certain abdominal operations satisfactorily, though familiarity with it would help even in the abdomen. In the neck, however, a surgeon who is unfamiliar with the structure of the neck can hardly hope to muddle through a serious operation without meeting disaster. There are certain general principles applicable to operations in the neck, the axilla and the groin, which should always be borne in mind. The chief dangers are from ignorance of anatomy and the inability to meet emergencies promptly. When an extensive neck operation is undertaken, the first essential is a satisfactory and thorough exposure of the parts involved. The large vessels and the nerves should be identified. It is best first to expose and identify the important vessels and nerves and then dissect away from them. If the operator is in dread of cutting a big vessel or injuring a nerve and plans his dissection to avoid these structures, he will either blindly injure them or else he will do an incomplete operation. By exposing the important vessels and nerves first and becoming familiar with them, the difficulties and dangers of the operation are greatly reduced.

Hemorrhage is often thought to be the chief danger in neck operations. Bleeding can be reduced by elevating the head and body of the patient. I formerly employed the sequestration anemia of Dawbarn, but finding that the patients did not do well toward the end of a tedious operation I abandoned it. As has been discussed in a previous chapter (p. 57), sequestration anemia produces shock.

If the operation does not involve entrance into the mouth, pharynx, or air passages the patient should be well under the anesthetic, because in the early stages of anesthesia there is great congestion of the head and neck and considerable blood may be lost from the excessive congestion.

The incision in the skin is undermined along the edges to secure the bleeding points at a distance from the edges of the cut skin. Every bleeding point is clamped and, if possible, vessels are doubly clamped before being divided. Dissection about the internal jugular vein, about the base of the neck, with the patient's head elevated carries the danger of opening the veins and of aspiration of air into the veins. This is always a serious accident and may be fatal.

If such an accident occurs the opening should be promptly closed by a wet sponge or by the finger and the wound flooded with salt solution. The veins should be compressed on the central side of the wound. If the injury to the vein is inaccessible, the wound is packed with gauze wrung out of salt solution and left in position for four days when the gauze is gradually removed while keeping the wound flooded with salt solution. Occasionally, from an old infection or from broken down glands, small veins become infiltrated and stiff and when cut do not collapse promptly. Here when a hissing sound is heard, which is peculiar to the aspiration of air, the suspected point is at once compressed with the finger, or clamped, or, if it is impossible to locate the wounded vein, a compress of wet gauze is applied.

While dissecting in the neck it is always safer to clamp doubly before dividing any strand of tissue that may be a vein. The late J. B. Murphy when doing a dissection of the neck exposed the lower part of the wound first and placed a small pack of gauze which made pressure upon the internal jugular vein and so distended it that it was easily recognized during the operation. The danger of hemorrhage from a wound to the internal jugular is far less than of aspiration of air, which is always a serious occurrence. The structures being removed during dissection of the neck should not be pulled upon too forcibly while being cut unless they have been previously relaxed and the veins which run to the structures have been given an opportunity to fill with blood. Dissection around the large vessels should be done as far as possible with a sharp knife, though gauze dissection may be employed after the vessels are freed. A dull knife will pull and hack tissue and it is impossible to tell how much force it is necessary to apply to each stroke of the knife.

In neck operations the adjacent lungs and pleura at the base of the neck must also be borne in mind. On the left side at the root of the neck the thoracic duct may be injured while dissecting in this region.

CYSTIC HYGROMA AND CONGENITAL CYSTS

Hydrocele, or cystic hygroma, of the neck is lined with endothelium and is almost always in the lower part of the neck behind the sternomastoid muscle. This growth has an intimate connection with the internal jugular vein and is developed from embryonic lymphatic tissue. It is quite different from the cystic tumors in the floor of the mouth, so-called ranulæ, or in the region of the submaxillary gland. If a hygroma is not large and there are no pressure symptoms, simple aspiration with compression or the application of x-ray or radium may be tried. If extirpation is decided upon it will frequently be found impossible to remove all of the sac, and extirpation of a portion of the sac, packing the rest with gauze, is often all that can be done. Sometimes the sac may be opened and sutured to the edges of the skin and, after evacuating the contents, packed with gauze, which is removed every few days until the wound gradually closes. Before packing the sac it may be swabbed with pure carbolic acid followed by alcohol.

Branchial cysts, or branchial fistulas, result from an incomplete closure of the branchial clefts. When the branchial cyst ruptures through the skin a fistula is formed. A frequent opening for this fistula is along the lower portion of the sternomastoid muscle, or the opening may be higher up close to the angle of the jaw, depending upon the cleft from which the branchial fistula was derived. A branchial fistula may be complete, when it extends from the skin of the neck to the pharynx or esophagus, or incomplete when a blind one. Sometimes it will be blind for a short distance but the end of the fistula will be closely attached to a cord, which probably means that this portion of the fistula has been obliterated. This cord, however, frequently contains embryonic rests that may cause further trouble unless the cord is removed along with the fistula. The dissection for removing a branchial fistula should not be lightly undertaken. Previous to the operation the fistula is tested to see whether it is complete by injecting into it some salt solution under considerable pressure, and ascertaining if the patient can recognize that the salt solution goes into the pharynx. If it does, and a probe can be made to follow into the pharynx, the dissection is much easier when a probe is inserted. Frequently, however, these tracts are very tortuous and are incomplete. Injecting the fistula with methylene blue is of service in demonstrating the fistula during its extirpation.

An incision is made along the anterior border of the sternomastoid muscle including the orifice of the fistula. The carotid artery and the internal jugular vein are first exposed and identified. The fistula with a small amount of skin surrounding its orifice is dissected from below upward. It usually follows the deep vessels of the neck in its course and is intimately associated with them, particularly in the upper part of the neck. By dissecting the vessels freely and exposing them carefully the chief danger is avoided. The fistulous tract must be followed as far as it goes. If it opens into the pharynx, F. Koenig mobilizes the fistulous tract to a point above the digastric muscle and then by blunt dissection separates it to the neighborhood of the pharyngeal mucosa. At this point the mouth is opened. A stout probe with the eye at the end or a large pedicle needle is passed through the wound appearing in front of the lower margin of the tonsil. The probe is cut down upon and a stout silk thread is fastened to it. This is withdrawn into the neck wound, a portion of the fistulous tract that has been dissected free is tied to the thread and by this means pulled into the mouth and fastened with a few stitches to the mucosa in front of the tonsil, the redundant part being cut away. The wound in the neck is completely closed.

A median fistula of the neck usually arises from the nonobliteration of the thyroglossal duct which leads from the foramen cecum on the tongue to a lower point in the neck. This duct is always closely connected to the body of the hyoid bone. Occasionally at the upper portion of a fistula of this type a tumor containing thyroid tissue occurs.

The results of operations for cysts or fistulas of the thyroglossal tract

are often unsatisfactory because the dissection is not sufficiently thorough. W. E. Sistrunk,[1] of the Mayo Clinic, describes an operation for excision of thyroglossal cysts or fistulas, which is founded on sound principles and gives excellent results. The operation, he says, is usually unsuccessful unless the whole epithelial lined tract from the cyst to the foramen cecum in the tongue is completely removed. The portion of the tract around the hyoid bone is difficult of dissection. The principle of the operation is to dissect out not only the tract but an amount of tissue for about an eighth of an inch on all sides of the tract, "coring" it out, between the hyoid bone and the foramen cecum. The tract lies at an angle of forty-five degrees from the upper sur-

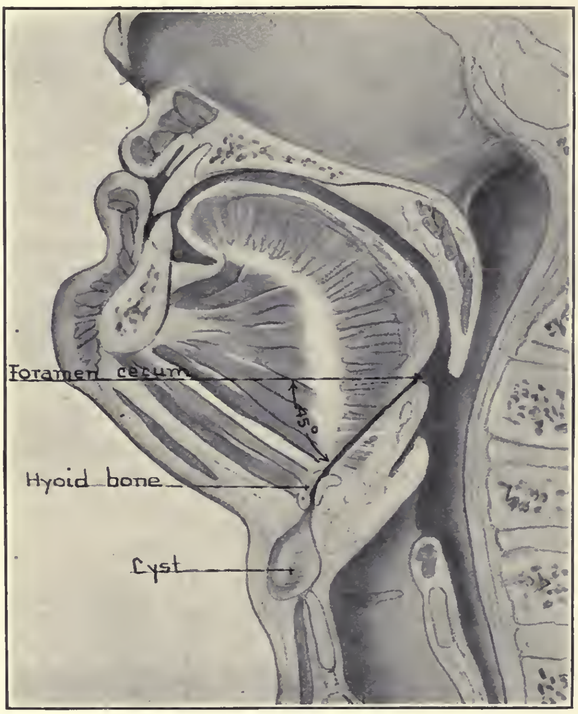

Fig. 335.—Cross section showing the relations of the cysts and fistulas of the thyroglossal tract, according to Sistrunk.

face of the center of the hyoid bone in the midline of the neck, backward and upward to the base of the tongue (Fig. 335). According to Sistrunk a transverse incision two inches long is made at the upper level of the hyoid bone and the skin and platysma are reflected. The cyst is beneath the raphe connecting the sternohyoid muscles and is freed from the surrounding tissue up to the hyoid bone where the tract usually passes through it. The muscles attached to the center of the hyoid bone are freed and a portion of the bone about a quarter of an inch long is resected. From this point to the foramen cecum there is no attempt to dissect out the thyroglossal duct,

[1]Ann. Surg., February, 1920, pp. 121-123.

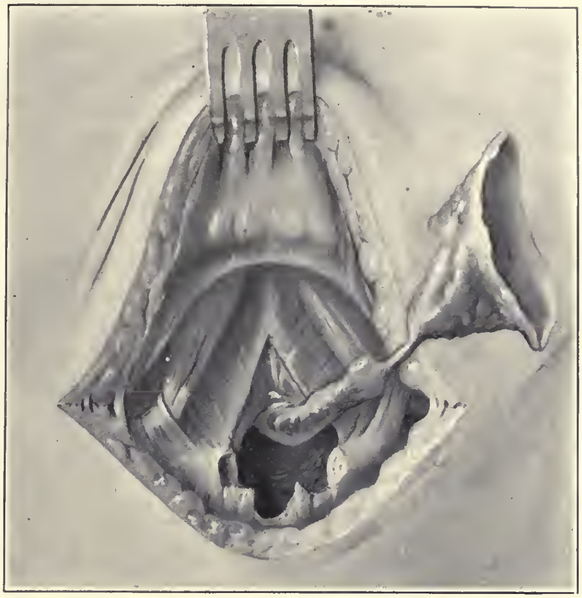

Fig. 336.—The middle segment of the hyoid bone is removed and the thyroglossal tract is dissected. (Sistrunk.)

Fig. 337.—The dissection has been completed, and the foramen cecum is exposed.

but the tissue is removed, as a core, to the foramen cecum at an angle of about forty-five degrees (Fig. 336). The core is about a quarter of an inch in diameter. The dissection removes a portion of the hyoid bone, a portion of the raphe joining the mylohyoid muscles, part of each genio-

hyoglossus muscle, and the foramen cecum (Fig. 337). The wound in the mouth is closed, the geniohyoglossus muscles are brought together with sutures, and the soft tissue over the ends of the hyoid bone are approximated with tanned catgut sutures to bring the ends of the bone together. A small drain of rubber tissue may be carried to this point and the skin closed around it.

CERVICAL RIBS

Excision of a cervical rib is indicated when pressure symptoms on the subclavian vessels, or on the brachial plexus, are sufficiently severe to demand relief. Sometimes the rib itself is short but is continued forward by connective tissue bands which give rise to symptoms. The operation, which is always difficult, may be done through a transverse incision above the clavicle and going from the sternomastoid to the trapezius muscle. If the rib is prominent and the protuberance can be palpated the incision is made in such a manner as will give the best exposure. Dissection is carried carefully down, doubly clamping and tying the external jugular or other veins until the brachial plexus and the subclavian vessels are seen. They should be gently and carefully retracted. The rib is separated from the adherent soft parts by sharp or blunt dissection, taking care to avoid injury to the pleura. If possible the periosteum is removed along with the rib to prevent the re-formation of the rib. After exposing the rib in front of the subclavian vessels and brachial plexus it is divided with bone forceps. During this division the subclavian vein is carefully retracted. It is similarly divided as close to its origin from the vertebra as possible and the rib is gradually loosened and removed. The bleeding points are carefully tied before closing the wound. In this manner all of the rib that can have any injurious pressure effect is removed.

TORTICOLLIS

Numerous operations have been devised for torticollis, but probably the most satisfactory is the excision of a portion or all of the sternomastoid muscle, except in those cases in which the torticollis is of the spasmodic variety when excision of a part of the spinal accessory nerve may be indicated.

In excision of the sternomastoid muscle, as recommended by Mikulicz, an incision is made along the middle of the lower portion of the sternomastoid muscle extending upward from the clavicle. The sternal and clavicular origins of the sternomastoid are exposed by dissection and the muscle is separated from the surrounding tissue. After isolating the muscle, it is divided near its origin and about half way between its origin and insertion. It is important to search for any cicatricial contracting bands and to divide or excise them thoroughly before the wound is closed.

If the torticollis is spasmodic this operation will bring relief because it destroys the function of the muscle, but the lower end may become attached to tissue in the neighborhood and cause trouble. Here it is best to destroy the

nerve supplying the sternomastoid which is the spinal accessory nerve. This nerve may be exposed by an incision which has been described in the operation for anastomosis of the facial and spinal accessory nerves. The incision is made about three inches in length from the mastoid process downward along the anterior border of the sternomastoid. The muscle is dissected free anteriorly, the cervical fascia incised, and the muscle retracted backward. The transverse process of the atlas, which is covered by the digastric muscle, is recognized with the finger. The spinal accessory nerve passes between this process and the muscle and emerges at the lower edge of the digastric to enter the sternomastoid muscle. About half an inch of the nerve can be excised at this point.

TUBERCULAR GLANDS OF THE NECK

Tubercular glands of the neck require different types of operations, depending upon their location. The operation is not so extensive, nor is the dissection so radical, as in operations for malignant diseases. The glands to be removed are frequently located in the upper part of the neck, but the whole side of the neck from the mastoid to the clavicle may occasionally be involved.

Dowd, of New York, recommends incisions so placed that they will fall in the natural creases of the neck, and so smaller scars result. In the upper portions of the neck an incision parallel with and about one or one and one-half inches below the border of the lower jaw, usually gives satisfactory exposure. Care must be taken in making such an incision to avoid the branches of the facial nerve that go to the muscles that depress the angle of the mouth. From the cervicofacial division of the facial nerve comes the mandibular branch which supplies the platysma and the depressor anguli oris. This courses along the tissues about the lower border of the jaw and if protected by an incision made well below the lower border of the jaw is not disturbed. For this reason the incision should be made as indicated and carried through the platysma before the edges of the wound are retracted or dissected up. If several glands are involved together and particularly if they are matted to one another it is important to have a satisfactory exposure. This is accomplished by dissecting the lower portion of the glands, if they are located in the inframaxillary region, and first freeing the mass of glands from below and in front. If the submaxillary gland is involved, the facial vessels are exposed after dissecting the mass of tissue backward and upward, and are doubly clamped and divided. Traction upon the mass will then show the points of attachment which can be divided. It must always be borne in mind that glands follow the general course of the veins and when the glands are abundant and adherent it is wise to expose the large veins in the neighborhood, dissect them free, and then remove the glands by dissecting from the vessels toward the glands instead of in the reverse direction. If the glands extend toward the internal jugular, this vessel is exposed by continuing the dissection below until the vein is reached. In closing the wound if a consid-

erable mass of glands has been removed a cavity of some size will be left. Here a small drainage tube is inserted through a short stab wound made, preferably, in a crease of the neck below the incision. The incision is closed carefully. Care is taken to approximate the platysma in closing all neck wounds, because if this is not done the action of the muscle will broaden the scar. If the skin has not been involved by the tubercular process it is best to approximate the platysma and subcuticular tissue by a continuous suture of fine tanned catgut before closing the skin. When this is done a continuous suture of fine silk or fine silkworm-gut in the skin leaves a very small scar, particularly if the incision has been made in the crease of the neck. Fine silkworm-gut may be used as a subcuticular suture.

Tubercular glands occasionally are so extensive that they require an incision that cannot be made to conform to the creases of the neck. Here it should be so placed as to render the tubercular glands easily accessible. The scar is less conspicuous if placed along the posterior border of the sterno-mastoid muscle, but if the glands bulge forward it will be necessary to make the incision along its anterior border, though this makes a more prominent scar. The scar can be greatly lessened by closing the wound carefully, uniting the platysma and subcuticular tissue with catgut and the skin with fine silk or silkworm-gut and removing the sutures in the skin as soon as possible.

MALIGNANT GROWTHS OF THE NECK

The malignant tumors of the neck that may be benefited by operation are either primary tumors such as spring from a branchial cyst or fistula, or metastatic carcinoma in the lymph glands derived from a primary cancerous focus in the head, face or mouth. Primary malignant tumors of the lymph glands, lymphosarcoma, or the tumors of the lymph glands in Hodgkin's disease, are practically always inoperable. There is probably no well authenticated case on record of lymphosarcoma of the neck that has been permanently cured by operation. Yates and Bunting have done very extensive work with Hodgkin's disease and feel that they have cured some cases by combination of radical operation, x-ray, and vaccine. In their later work, however, they do not seem so enthusiastic about the ultimate results as they were at first. It is possible that excision of the glands in Hodgkin's disease, if done radically, may delay the fatal issue, particularly if followed by internal administration of arsenic. Occasionally, marked temporary benefit is obtained, but permanent cure rarely if ever follows these procedures. The application of x-ray or radium by some one who is skilled in such work seems to offer more hope in cases of this type than operative procedures.

In metastatic carcinoma of the lymph glands of the neck, however, operation is often followed by excellent results and radical surgery offers far better prospects of cure than any other method of treatment. The operation to be successful must be properly planned and executed. In carcinoma about the mouth or face it is advisable to do block dissection of at least the upper portion

of the neck even though there are no glands that are palpably enlarged, unless the cancer is a basal cell cancer. Here dissection of the neck is unnecessary. The neck dissection can usually be done when the growth in the mouth or face is removed and should be the first stage of the operation as the chances of infection are greater if the procedure is reversed.

To appreciate the lymphatic drainage of the neck and intelligently to plan a radical operation in this region, the anatomy of the lymphatics and the lymph glands, which has been carefully worked out by Poirier and Cuneo, must be borne in mind. The lymph glands or nodes of the neck form, roughly speaking, a collar at the junction of the head and neck. On each side of this collar there is a chain of glands that follows along the internal jugular vein and behind the sternomastoid muscle down to the upper portion of the thorax. This upper circle of glands consists of five groups:

(1) The suboccipital group consists of from one to three glands, which rests on the complexus muscle just external to the border of the trapezius. These glands drain the posterior portion of the scalp and their lymphatics open into the upper glands of the sternomastoid group.

(2) The mastoid glands are usually not more than two, situated about the insertion of the sternomastoid muscle. They drain the temporal portion of the scalp, the posterior surface of the ear, and the posterior surface of the external auditory meatus. Their lymph channels also open into the upper glands of the sternomastoid group.

(3) The parotid glands constitute a group which is rather numerous. They lie just beneath the parotid fascia or deeper in the substance of the parotid gland. They are not confined to any one part of the parotid gland. They drain into the upper glands in the sternomastoid group. There are also glands, sometimes called the subparotid nodes, that lie behind the parotid gland and drain the nasal fossa and the nasopharynx and empty into the upper glands of the substernomastoid group.

(4) The submaxillary glands, from three to six in number, are under the lower border of the jaw and rest on the mylohyoid muscle and on the submaxillary salivary gland. Often a lymphatic gland is imbedded in the submaxillary gland. This group is subdivided into anterior and posterior glands. The posterior glands are often very large and follow the course of the facial vein.

(5) The submental group of lymph glands are three or four in number and are deep in the space between the anterior bellies of the digastric muscles. They extend from the chin to the hyoid bone. They drain the middle portion of the lower lip and chin and the corresponding part of the lower jaw, the floor of the mouth, and the tip of the tongue. Lymph channels from these glands open either into the submaxillary group of glands, or go downward into the glands around the internal jugular vein about the middle portion of the neck. This group of glands may, of course, drain into both sides of the neck. The tissue between the region drained by the submental glands and that drained by the parotid glands is drained by the submaxillary group of glands.

The deep cervical lymphatic glands below the upper collar of lymph glands form a chain which reaches from the level of the transverse process of the atlas down to the upper portion of the thorax. These are numerous glands and follow the general course of the internal jugular vein. The upper part of this chain is beneath the sternomastoid muscle and the lower part is in the subclavian triangle. They are divided into the substernomastoid group and the supraclavicular group of glands.

The substernomastoid group of lymph glands extends from the level of the transverse process of the atlas to the subclavian vein. This group is subdivided into an external group, which follows the posterior border of the sternomastoid muscle, blending with the glands in the subclavian triangle; and an internal group, which is in close contact with the internal jugular vein and which drains the glands of the first five groups that have been mentioned. One of these glands which lies between the posterior belly of the digastric muscle and the internal jugular vein is very prominent, and has been called by Cecil Leaf the "jugulo-digastric gland." This gland receives directly or indirectly lymphatic drainage from the tonsils and palate, base of the tongue, the margins and some of the central portion of the tongue.

The supraclavicular group of glands, which lies in the posterior triangle of the neck, consists of numerous glands that are continuous above with the external group of the deep cervical glands. The lower glands in this group lie on the omohyoid muscle and along the lower portion of the external jugular vein and some of the branches of the cervical and brachial plexus. They drain the occipital region of the scalp and posterior part of the neck, the skin of the pectoral and mammary regions, portions of the arm along the cephalic vein, and some of the axillary lymph glands. This chain empties into the venous circulation through the thoracic duct, or by separate lymphatic trunks which open into the subclavian vein. There is no direct connection with the mediastinal glands, though of course, there may be retrograde processes that connect this group with the mediastinal glands.

It is readily seen, then, that an operation for removal of metastatic cancer of the neck must be undertaken always on the principle of a block dissection. If the involvement is slight removal of the glands in a mass from the upper portion of the neck may be all that is necessary, but where it is extensive the dissection must be made from the clavicle to the lower jaw and the mastoid process.

In operating for cancer the appearance of the resulting scar is not important but the incision is made to afford the greatest access to the tissues to be removed and to enable a block dissection to be done. These are the most important indications, and if rendering the scar inconspicuous does not interfere with them, this less important object may also be considered.

In block dissection of the upper neck if the primary lesion is well on one side of the midline the dissection may be limited to that side of the neck provided there is no evidence of involvement of glands on the other side of the neck. If, however, the lesion is in or near the midline, dissection of both sub-

maxillary regions should be done. If the glands are extensively involved on one side and not on the other it is best to do a block dissection on both sides of the neck, because the back pressure from the enlarged glands has probably forced cancer cells to the other side.

If both sides of the neck are to be operated upon an incision is made beginning over the sternomastoid muscle just below and posterior to the angle of the jaw and is carried forward about one inch below the lower jaw to a corresponding point on the sternomastoid muscle on the opposite side. By extending the neck and elevating the chin the tissues are made much more accessible. Theoretically, the dissection should begin on one side and extend to the other, but this is much more difficult than beginning in the midline under the chin and dissecting backward. If, however, the midline dissection is made with an electric cautery and the tissues in this region are thoroughly cauterized, the block dissection on either side can be safely started from the midline. The skin dissection is carried below and the tissues are dissected from below and from the midline backward and upward. Some fibers of the geniohyoid and mylohyoid muscles may be included in the mass of tissue, but the digastric can be preserved intact by working from before backward and from below upward. The line of cleavage of the fascia and the gland bearing tissue is readily found. The facial vessels are exposed, doubly clamped, and divided. The mass is then separated at its upper margin, the surgeon having previously dissected up the skin and platysma. The facial vessels are doubly clamped and divided at the margin of the jaw bone and the duct from the submaxillary gland is clamped before it is divided. The mass is separated from the sternomastoid muscle and the deep jugular vein. If the skin is not involved along the upper margin of the wound the precautions about preventing injury to the mandibular branch of the facial nerve, which were mentioned in connection with operations for tubercular glands in this region, should be borne in mind; but if there is a suspicion of involvement of the skin or subcutaneous tissue in this neighborhood there must be no hesitancy in sacrificing this nerve.

During the dissection the wound is flushed frequently with salt solution to wash out cancer cells that may have been freed during the dissection. If there is a point of suspicious cancerous involvement which it is not thought wise to include in the mass, it is cauterized with electric cautery provided, of course, it is not the wall of a large vessel. Tube drainage is provided for by a stab wound made posteriorly. This, as has already been explained, drains the lymph that is poured out into the wound following the dissection and encourages reversal of the lymphatic circulation to expel the tube. In this way cancer cells that might otherwise be absorbed are flushed out of the wound by the reversed lymph supply and emptied through the drainage tube. The wound is closed by interrupted sutures of silk or silkworm-gut or, if the dissection permits, a deep row of continuous catgut sutures in the platysma, followed by interrupted sutures of silk or fine silkworm-gut in the skin, will make a nicer scar.

If the lymph glands are involved below the inframaxillary region or if they are markedly enlarged in the inframaxillary region, it is best to make a

block dissection of the entire side of the neck. This operation was first described in a systematic manner by Crile. Crile's upper incision goes from behind and below the mastoid process forward beneath the jaw, terminating in the midline just beneath the chin. Another incision begins about the junction of the posterior and middle thirds of the first incision and goes down over the middle of the sternomastoid muscle to the lower border of the clavicle. If necessary a horizontal incision can be made either forward or backward from the lower end of the sternomastoid incision. The skin and platysma are widely dissected along the margins of the wound. The sternomastoid muscle is freed from the carotid artery and the internal jugular vein and is doubly clamped and divided. The sheath which surrounds the carotid artery, jugular vein and the vagus nerve is opened and the vein is freely exposed. Care is taken to identify the carotid artery and the vagus nerve. The jugular vein is doubly ligated in its proximal portion just above the clavicle. Ligatures are placed about one-quarter of an inch apart and are of catgut. Another ligature or clamp is placed at a safe distance about the second ligature and the jugular vein is divided just below the upper ligature or clamp. The tissues of the neck, including the sternomastoid, the jugular vein, fat, fascia and glands in the neighborhood are dissected up in one mass.

Crile advises placing a soft clamp on the common carotid artery for temporary hemostasis but this seems unnecessary. The bleeding is readily controlled by hemostats, and when the bifurcation of the common carotid is reached the external carotid is doubly ligated a short distance above the bifurcation. As the dissection continues leaving the common and internal carotid arteries and vagus and phrenic nerves, the facial, lingual and occipital branches of the external carotid are also tied. The submaxillary space is dissected from in front and below upward and backward, as has already been described, and is separated from its upper connection leaving this mass of tissue attached posteriorly to the main mass around the sternomastoid muscle and the internal jugular vein. The sternomastoid muscle is severed from its insertion just below the mastoid process, and the fascia and tissue in its neighborhood are carefully dissected forward until the upper portion of the internal jugular vein is exposed. This is recognized because it is strutted with blood, being clamped below. The vein is ligated as high up as possible just as it was ligated above the clavicle, passing two catgut ligatures about one-quarter of an inch from each other, clamping and dividing the vein below the second ligature. The internal carotid and the vagus nerve are identified during this ligation. The attachment of the mass of tissue which is just below the parotid gland and the posterior angle of the jaw is cut away with a sharp knife (Fig. 338). Often a portion of the parotid gland is wounded and the bleeding from this region may be annoying. It is readily controlled, however, by whipping it over with sutures of catgut. The wound is frequently flushed out with salt solution during the operation. Suspicious points may be touched with the electric cautery, particularly at the root of the neck, though care must be taken in this region not to injure the pleura or the thoracic duct. A drain-

age tube is placed through a stab wound in the skin posterior to the wound. The wound is closed as in the block dissection in the upper part of the neck. The lymphatic drainage from such a wound is very extensive for the first twenty-four hours and it may give the impression of a hemorrhage. If proper care is taken to ligate or suture all bleeding points there should be no danger of secondary hemorrhage, unless there is infection. The large lymphatic trunks that have been cut will naturally pour out an abundant supply of lymph.

Fig. 338.—A completed block dissection of one side of the neck.

If the operation just described is undertaken in connection with resection of a portion of the jaw for cancer, the cavity of the mouth will necessarily communicate with the wound and infection will probably occur. Here secondary hemorrhage may be feared. As the common carotid is left by the dissection just beneath the skin, it can be readily compressed or by removing a few sutures or incising the skin it can be clamped. Such an accident, however, is always serious, though the great value of the block dissection in cancer makes it seem wiser to risk such a danger in the hope of a cure of the cancer than to undertake the operation in two stages when there will necessarily be

a break in the block dissection. Even when the tissues are cauterized if there is an interval of several days between the mouth operation and the neck operation, there is danger of the cauterized tissue being absorbed and cancer cells being transported from the primary focus into the extensive wound made by the operation in the neck. Cauterization of tissue will seal the lymphatics, destroy cancerous tissue in the neighborhood, and render the tissues temporarily safe from invasion of cancer but this immunity passes off in a few days when the tissue that has been destroyed by the cauterization has been absorbed and the lymphatics have again opened up.

THE LARYNX AND TRACHEA

Operations upon the larynx are usually for malignant disease. When the cancer is confined to one of the vocal cords, or if only a small portion of the larynx is involved, or if the growth is benign, a satisfactory operation is laryngotomy. An incision is made in the midline, extending from the hyoid bone to the first ring of the trachea. The cricothyroid membrane is divided and the thyroid cartilage is carefully split in the midline. This is done with strong scissors or a thin-bladed bone forceps. When the cartilage is very hard a fine saw may be used. The lateral halves of the thyroid cartilage are retracted with sharp hooks and the interior of the larynx is sprayed or gently mopped out with a one per cent solution of cocaine. Attention is given to hemostasis and no blood is allowed to flow into the trachea. If the growth is malignant it is best to remove it with the electric cautery.

Many operators perform the first step of laryngotomy or laryngeal fissure by making a low tracheotomy. If the operation in the larynx is to be extensive this is a wise procedure, but if not, the thyroid cartilage can be united by two sutures of catgut and the wound closed. A small tube or piece of gauze is placed in the lower angle of the wound leading down to the thyroid cartilage in order to prevent emphysema which may occur if there is a spell of coughing and the skin is closed too tightly.

Tracheotomy may be the first procedure in a laryngeal operation. When a tracheotomy is an emergency operation and when there is danger of asphyxia it can be quickly done by a stab of a knife. Usually in such emergencies an incision in the cricothyroid membrane with the insertion of a forceps, which is spread open, is all that is necessary. Before attempting tracheotomy in emergency cases the patient is given, if possible, a dose of morphine and atropin hypodermically. This not only lessens the excitement of the patient, but the atropin serves to lower the sensibility of the terminals of the vagus nerve in the heart and so diminishes the danger of reflex inhibition of the heart. It also has a very beneficial effect in decreasing the amount of mucus. In emergency cases the operation is done under local anesthesia and in grave emergencies a stab wound is quickly made in the midline of the trachea.

In cases that are not urgent emergencies the trachea may be opened either in its upper portion where it is more accessible or lower where the trachea

is deeper. A transverse incision in the skin makes the best scar, but where tracheotomy is indicated the scar is often a minor consideration. The incision, whether transverse or vertical, is made, and the isthmus of the thyroid, if it interferes with the dissection, is divided down to the trachea. The raw surfaces of the thyroid gland are whipped over with sutures of catgut to control bleeding and retracted to each side out of the way. After the trachea is fully exposed the tissues between the rings are carefully infiltrated with novocain solution to which has been added a small amount of epinephrin. It is highly important to prevent blood gaining access to the trachea and infiltration, particularly when epinephrin is added, lessens bleeding. The trachea is divided between the rings with a transverse incision. If more room is needed the rings are cut across, but usually this is not necessary. If, however, a tracheotomy tube is to be worn for a considerable length of time it may be necessary to divide one or more of the tracheal rings. As soon as the trachea is opened the mucosa is anesthetized by spraying with a small amount of one per cent cocaine solution or two per cent novocain solution. This is applied very gently and no further procedure is taken until a few minutes have elapsed for the anesthetization of the mucosa. A good way to anesthetize the tracheal mucosa is to inject with a hypodermic syringe a few drops of a two per cent cocaine solution into the lumen of the trachea between its rings. This is done after exposing the trachea and a few minutes before opening it. After being incised the trachea is held open by small sharp retractors and a tube is gently inserted. In an emergency a large drainage tube can be used, the outer end being split in half and these halves immobilized by being tied to tapes which meet around the neck. Or a piece of wire or a hair-pin can be bent in such a shape as to keep the trachea open.

The air of the patient's room must be warm and moist. Loose gauze that is kept constantly moist is placed over the tracheotomy tube. If a regular tracheotomy tube is used it will be necessary to clean the inner tube frequently as soon as it is apparent from the breathing that an excess of mucus has accumulated. The dressings over the wound and tracheotomy tube are frequently changed.

When it is necessary to close a tracheotomy wound the scar is dissected from the normal tissue, the wall of the trachea infiltrated with novocain and epinephrin, and freshened. On release of the scar the trachea usually falls together and if the skin and superficial tissue have been thoroughly mobilized it is usually not necessary to put sutures in the trachea.

When there is a stricture of the trachea, which may follow the long wearing of a tracheotomy tube or may result from ulceration, the problem is quite difficult. The most satisfactory operation, in the opinion of Crile, is resection of the strictured area. The trachea is then united by mattress stitches of silver wire which include a ring of the trachea above the stenosis and one below it. Three sutures of rather heavy silver wire are placed, one on each side of the esophagus and one in front. Crile leaves the front end long so it emerges from the wound and twists the sutures until apposition of

the tracheal wound is satisfactory. This presupposes that the rings of the trachea are normal and are not softened by disease or inflammation.

In laryngectomy it is highly important to select an appropriate anesthetic. A. D. Bevan prefers to do a laryngectomy under local anesthesia. The operation, which is often rather long and tedious, is quite trying on the patient if done under a local anesthetic, though the danger may be thereby decreased. Bevan does a laryngectomy in one stage and apparently feels that the preliminary procedures, as tracheotomy and partial dissection of the larynx, are not necessary. The rectal anesthesia method of Gwathmey seems ideal for lar-

Fig. 339.—Lines of incision for laryngectomy.

yngectomy, but if for any reason this is not preferred, a large, snugly fitting rubber tube that is well lubricated is inserted into the trachea and the anesthetic administered through this tube, which is connected with a funnel over which is stretched a few layers of gauze, the ether being dropped on the gauze. Care should be taken to hold the tube and the funnel in such a manner that no liquid ether can gain access to the trachea. This method of giving the anesthetic should not be employed unless there is some positive contraindication for the use of the Gwathmey rectal anesthesia, or local anesthesia.

A vertical incision is made along the median line from a point just above the hyoid bone to the border of the sternum. A transverse incision is made

just above the hyoid bone making with the median cut a T-shaped incision (Fig. 339). If necessary a similar transverse incision can be made at the lower end of the vertical one. If a tracheotomy has not been previously done the same steps of dividing the isthmus of the thyroid gland and controlling the bleeding surface by whipping it over with catgut as has been described under the technic of tracheotomy are taken. The tissues are dissected freely from each side of the larynx, separating and dividing the sternohyoid and sternothyroid muscles on each side, as well as the thyrohyoid at its in-

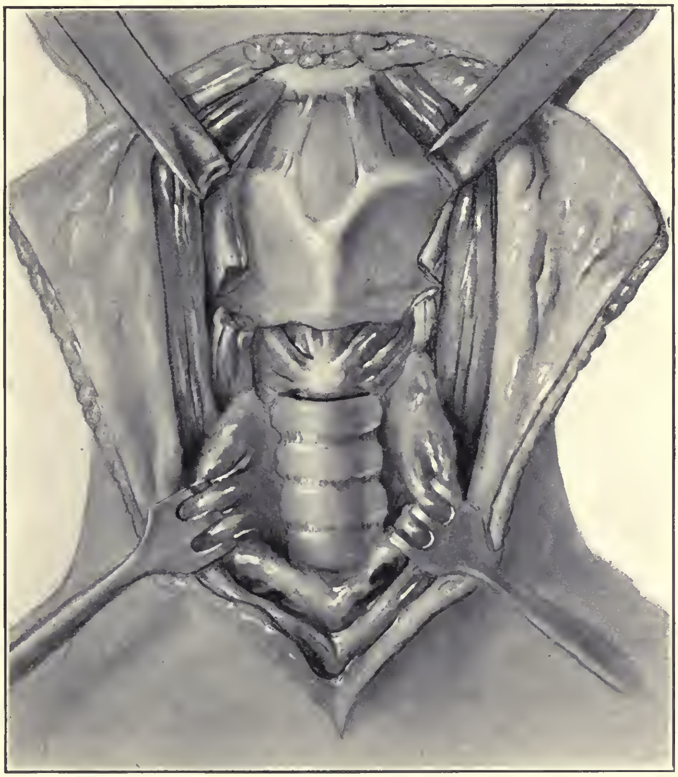

Fig. 340.—The larynx has been exposed and partly mobilized. In the next step of the operation the trachea is severed from the larynx.

sertion into the thyroid cartilage. The larynx is completely freed as far as possible on each side (Fig. 340) and then after infiltrating the space between the upper ring of the trachea and the cricoid cartilage in order to lessen bleeding, a few drops of a two per cent solution of cocaine are injected into the lumen of the trachea with a hypodermic syringe. After a few minutes the mucosa of the trachea and larynx is anesthetized. Then the trachea is cut across. The dissection is continued and the larynx is separated from the esophagus behind. If a tracheotomy tube is not used, the trachea, after being divided, is separated from the esophagus for a distance of an inch or more, and brought forward and sutured to the skin. Great care is taken to see

that there is no oozing or trickling of blood into the trachea. Gauze is lightly packed just behind its posterior cut margin to control bleeding. Bevan thinks that patients do much better without a tracheotomy tube. After disposing of the stump of the trachea the larynx is seized with forceps and pulled upward toward the chin and the dissection from the esophagus is continued to the upper extremity of the larynx behind. The esophagus is incised and the larynx is cut away at its upper portion, dividing ligaments and muscles that are attached laterally to the larynx, and finally, the thyrohyoid membrane. The entire larynx, usually with the epiglottis, is removed

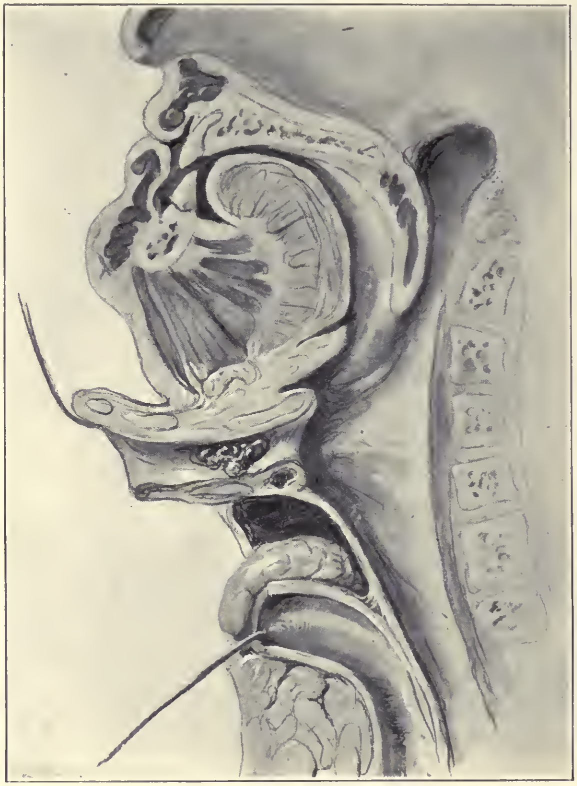

Fig. 341.—The trachea has been divided and brought to the skin. The larynx is being dissected out from below upward.

in one mass (Fig. 341). The wound in the esophagus and pharynx is closed by continuous silk or linen sutures. The sutures are applied as snugly as possible in an effort to prevent leakage, but if made too tight or too numerous necrosis will occur and the wound will break down. Wherever possible the sutured opening in the pharynx is reinforced by drawing soft tissues in its neighborhood over it. The skin wound is closed, leaving iodoform gauze drainage at the lower portion of the wound just above the stump of the trachea and at each end of the transverse incision along the hyoid bone (Fig. 342). The patient is put to bed in the Trendelenburg position if the operation has been

done under a general anesthetic, but as soon as he recovers the head of the bed is elevated or he is placed in a semi-sitting position in bed. Water is supplied by rectal enemas, or if necessary by hypodermoclysis. After two days, feeding is undertaken by introducing a large soft rubber catheter through the mouth into the esophagus well below the level of the larynx. Through this catheter, which is attached to a funnel, liquid nourishment can be gradually

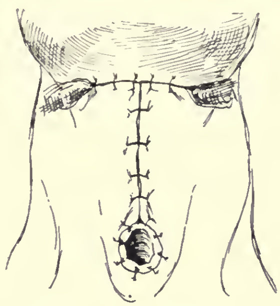

Fig. 342.—The laryngectomy completed.

poured. In this way leakage of food through the pharyngeal wound is avoided. This method of feeding can be kept up for about two weeks.

PHARYNX AND ESOPHAGUS

Occasionally it is necessary to have access to the pharynx from the neck. This is obtained by an incision above the hyoid bone and parallel to it. The submaxillary gland is retracted and the digastric muscle is recognized and preserved. Other muscles of the neck, that is, the mylohyoid, geniohyoid, and the hyoglossus are divided transversely. The posterior part of the tongue is pulled into the wound with sharp retractors. The pharynx may also be entered by an incision below the hyoid bone and parallel to it. If entrance to the larynx is desired a short incision of two inches is sufficient but if the pharynx farther back is to be reached the incision should be much longer. The thyrohyoid membrane is divided along the posterior portion of the hyoid bone, but enough of this membrane is left attached to the bone to hold the sutures. The mucosa is divided, taking care to avoid injury to the epiglottis. Sutures in the mucosa along the edge of the wound act as retractors. The epiglottis is pulled into the wound and a tractor suture is inserted into it. The wound is closed by uniting the thyrohyoid membrane and the muscles in separate layers with catgut. It is best to insert a small drain.

To remove a tumor or a foreign body that has lodged in the esophagus an incision is made on the left side beginning at the upper level of the larynx and going down along the anterior border of the sternomastoid muscle for three or four inches. The incision is deepened and the omohyoid is divided or retracted. The thyroid gland and the trachea are retracted toward the midline, and the common carotid, internal jugular vein and vagus nerve

are retracted outward in their sheath. The esophagus is exposed and if a foreign body is present and can be felt an incision is made in the axis of the esophagus down to the foreign body. Before incising the esophagus it is best to fix its wall by tenacula forceps or by insertion of sutures that will act as tractors. If the incision is made for a tumor and the esophagus is not readily exposed an esophageal bougie is inserted through the mouth to make it prominent. To avoid the recurrent laryngeal nerve, the incision is made in the side of the esophagus and not in front of it. The wound is closed by interrupted sutures of fine catgut in the esophagus, which should not be tied too tightly. The rest of the wound is partially closed, leaving abundant drainage down to the esophageal wound in order to provide drainage if the wound in the esophagus leaks, which it frequently does, and also to guard against mediastinitis, which is a considerable danger in these cases.

An esophageal diverticulum may occur from pressure within the esophagus or from traction without the esophagus, as from a contracting adhesion that involves its walls. The latter form of diverticulum is rare, but occasionally occurs in that portion of the esophagus within the chest. The most common site of esophageal diverticulum is at the lateral and posterior portion of the junction of the esophagus and pharynx. Here there seems to be a weak spot as there is a weak spot at the internal opening of the inguinal canal where hernia often occurs. Pressure from swallowing makes a pouch at this weak spot at the beginning of the esophagus and the pouch may continue to enlarge until it attains considerable dimensions. When very large a diverticulum may interfere seriously with the passage of food. In operating, an incision is made as for esophagotomy, which has just been described. The tissues are retracted and usually the diverticulum is readily found. It is dissected free bluntly and brought into the wound. The safest plan is to pack the wound with gauze for about a week until granulations in the tissues have established a defense against infection and the occurrence of mediastinitis. If the diverticulum is a large one it is brought out of the skin wound and left in this position surrounded by gauze. A small diverticulum can sometimes be pulled up so that it stands at a right angle from the esophagus. A small amount of packing is placed below it and most of the skin wound is closed. At a second operation, a week or ten days later, care must be taken not to break through the barrier of granulations and coagulated lymph, particularly in the lower portion of the wound. The neck of the sac is cut away, the margins of the wound in the esophagus being clamped or sutured as the incision is made so as to prevent too great retraction of the esophagus. Care must be taken so to cut off the diverticulum as to leave no pouch when the stump is sutured. If, however, too much of the esophagus is removed a stricture may result. The stump is sutured preferably with catgut, and if possible this layer of sutures is inverted by a second layer. Iodoform gauze drainage is carried down to the wound in the esophagus and the skin wound is partially closed.

When the diverticulum is small it may sometimes be inverted into the

esophagus by a series of pursestring sutures, the first sutures being inserted near the tip of the diverticulum, inverting the tip, and the second farther down, inverting still more of the diverticulum, and so on until the last pursestring suture merely closes the dimple in the esophageal wall. This is the method practiced by A. D. Bevan, and if the diverticulum is small and thin and can be readily inverted the operation is done safely at one sitting, as the esophagus is not opened. The inverted diverticulum is supposed to atrophy or to slough off. In a large diverticulum or in one with thick walls this operation cannot readily be done and the two-stage operation with excision of the diverticulum, which is the method described by Judd and usually followed at the Mayo clinic, is preferable.

After any operation upon the esophagus the patient should be nourished as recommended after excision of the larynx. He is given enemas for the first few days and afterwards nourished through a small stomach tube passed through the mouth. Where the esophagus has not been opened, however, as when a diverticulum is inverted, there is no occasion for the use of the stomach tube though the swallowing should be restricted as much as possible for the first week by giving liquids by enemas and by administering only liquid nourishment by mouth.

In an esophageal stricture a pouch often forms above the stricture and renders the passage of a sound or bougie very difficult. When the stricture cannot be entered from above, Abbe has practiced gastrotomy and the insertion of a small whalebone bougie from below. This passes into the mouth and two stout threads are tied to the end of the bougie and drawn through from the mouth into the stomach. The threads act as a guide to an esophageal bougie, which is tunnelled and threaded over the end of the thread that protrudes from the mouth. After the esophageal bougie has engaged the stricture the second string is pulled upon with a see-saw motion so as to cut the stricture. Ochsner advises drawing a rubber tube under tension through the stricture so that when the tension is relaxed the tube expands and dilates the stricture. The tube is left in position for several days when a larger one is inserted, and so on until the stricture has been overcome. The patient, of course, is fed in the meantime through the gastrotomy wound. Occasionally a fine silk thread can be passed through a stricture by floating it in water and taking the water through a tube. After several days the thread may pass through the stomach and into the duodenum in such a way as to fix the end of it and the thread can be made taut and serve for the introduction of a bougie. S. J. Mixter, of Boston, has practiced this method with much success.

THE CAROTID GLAND

The carotid gland varies considerably in size and is found near the bifurcation of the common carotid artery. It is closely attached to the internal carotid and contains groups of epithelial cells which have a function through internal secretion probably connected with the function of the adrenal gland and

the sympathetic nervous system. Tumors of this gland have been found. Sometimes the tumors are quite malignant, but usually they grow slowly and are mildly malignant if not actually benign. The treatment of such tumors is very difficult to determine. If operation is deferred until the growth is large it will almost invariably be necessary to resect a portion of the carotid arteries involved in the growth. When the tumor is small the operation is less difficult, but even then the intimate association of the carotid gland with the carotid vessels makes it frequently impossible to remove the gland without serious injury to the walls of the carotids. Aside from hemorrhage the chief danger of the operation is in cutting off the blood supply to the brain by the ligation of the common and internal carotid arteries. This serious objection to the operation may be partially overcome by the employment of malleable bands that have been described in the treatment of carotid aneurisms, or by the use of Crile's clamp which can be nicely adjusted by a screw. By either of these devices the circulation through the internal carotid is gradually cut off until it is found that the common carotid can be completely occluded with safety. This may be weeks, but then it will be reasonably safe to tie the common carotid below and the external and internal carotids above and excise the growth. If it is found that the circulation to the brain cannot be sufficiently developed by this method after it has been given a satisfactory trial, and if the tumor appears to be malignant and endangering life, an attempt might be made to resect the carotid arteries and suture between the stumps of the common and internal carotid arteries a segment of the saphenous vein which is taken from the same patient. Indications for this operation will be very unusual, but such a condition may conceivably occur and if the surgeon can suture blood vessels satisfactorily the operation may give a chance in an otherwise hopeless situation. The suturing should be done as described in the chapter on Blood Vessel Suturing.

DIFFUSE LIPOMA OF THE NECK

Occasionally a diffuse lipoma of the neck is so large as to indicate operation. Often this is accompanied by symmetrical lipomas elsewhere and by nervous disturbances that would contraindicate operation upon the lipoma of the neck. If, however, the diffuse lipoma of the neck is the chief or only growth and there is no contraindication, the tumor may be removed through a long transverse incision over the most prominent portion of the growth. The dissection required is very extensive and the vessels are often greatly displaced. The dissection begins at one of the two extremities of the incision over the edges of the trapezius muscle, and extends forward after freeing the tumor above and below as much as possible. Care is taken to identify the large veins at the root of the neck and to guard against the entrance of air into the veins (Figs. 343 and 344). For this reason the vessels in the lower portion of the growth are identified and clamped before dissecting those at the upper portion. The external jugular veins are usually buried in

the mass of fat which extends into the crevices between the muscle plains and around the deep vessels of the neck. It is often impossible to remove all of a large diffuse lipoma in one mass, but if there is no distinct capsule it can be removed in sections if this renders the operation easier. The wound is washed

Fig. 343.—Photograph of a patient with large diffuse lipoma of the neck.

Fig. 344.—Photograph of patient shown in preceding illustration a few weeks after operation for removal of diffuse lipoma.

out with salt solution and dried with gauze to remove the fat that may be liquefied and squeezed into the wound during the course of the dissection. Drainage with tubes through small stab wounds on each side of the neck should be established.

THE CERVICAL SYMPATHETIC

Removal of the cervical sympathetic ganglia was formerly recommended by Jonnesco for exophthalmic goiter. It is no longer used for this purpose but has been occasionally done for unimproved exophthalmos after the thyroid gland has been operated upon and the other symptoms have disappeared. The operation has been done by C. H. Mayo in those cases of extreme exophthalmic and nervous symptoms that are out of proportion to the size of the thyroid. He removes the superior and sometimes the middle sympathetic ganglia, and at the same time ties the superior thyroid vessels. The operation is done through an incision whose center is on a level with the bifurcation of the common carotid artery. The sternomastoid muscle is retracted outward and the sheath containing the carotid vessels and the vagus and internal jugular vein is retracted inward. The superior sympathetic ganglion is about one-eighth to one-fourth of an inch wide and has many branches. After dividing the branches the upper ganglion is removed. The connecting nerves of the middle cervical ganglion are cut, or this ganglion may also be removed.

In Jonnesco's operation the incision is made behind the mastoid process along the posterior border of the sternomastoid muscle to just below the clavicle. The external jugular vein is doubly ligated and divided, the fibers of the sternomastoid muscle are split, and the ganglion is approached through this muscle splitting incision. The inner portion of the sternomastoid muscle along with the vessels and nerves in the carotid sheath is retracted inward, and upward. The sympathetic nerves are found either on the posterior surface of the sheath containing the vessels which have been retracted inward or on the vertebral column in a special sheath. The sympathetic nerve is followed upward until it is seen to communicate with the superior sympathetic ganglion. The ganglion is dissected bluntly from below upward, its branches are divided with scissors and the ganglion is removed. The inferior thyroid artery, as it crosses under the common carotid, is surrounded by a dense nervous plexus which consist of the sympathetic trunk with its branches. At this point enlargement of the sympathetic nerve forms the middle cervical ganglion. By making traction on the nerve trunk it is followed downward and the nerve is elevated and separated from the inferior thyroid artery. The inferior ganglion is the most difficult to remove and its removal is usually unnecessary. It lies deep in the base of the neck, just above the pleura, behind the clavicle and against the head of the first rib between the scalenus anticus and longus colli muscles. The trunk of the sympathetic is the guide to the ganglion which lies sometimes internal and sometimes external to the vertebral artery. The inferior sympathetic ganglion is adherent to the vertebral artery which makes its separation difficult. After exposing the vertebral artery the ganglion is caught with forceps and isolated from the artery externally and the rib and spine internally. Its nervous connection is severed and the ganglion removed. The wound is closed carefully without drainage.

This extensive operation is rarely if ever indicated, though removal of the upper and possibly the middle, cervical sympathetic ganglion as practiced by C. H. Mayo, may sometimes be beneficial under conditions that have been described by him.

THE THYROID GLAND

A simple goiter may be removed with the same general precautions observed in operating on any tumor of the neck, but a goiter with hyperthyroidism introduces a distinctively different problem. In the exophthalmic type of goiter thyroidectomy should not be done during the acute exacerbation of the disease when the pulse is running 120 or more and the symptoms of hyperthyroidism are pronounced. Here one superior thyroid artery is ligated, preferably under local anesthetic. If after five or six days but little reaction occurs, the second superior thyroid is tied, but if marked reaction shown by rapid pulse and elevation of temperature, occurs a few days after the first ligation, the second operation should be postponed, preferably for

several weeks. If the second ligation is followed by little or no reaction a thyroidectomy can be done in a week or ten days after the second ligation. If there is any marked reaction after the second ligation it is safer to send the patient home with instructions to return in two or three months for thyroidectomy. If after this time the patient has not improved materially, thyroidectomy should not be attempted, but the inferior thyroids may be ligated, or the goiter injected with a solution of quinine and urea, as has been very successfully done by Leigh Watson, of Chicago, or by hot water, as practiced by Miles Porter, or treatment by a competent roentgenologist should be instituted. The technic of ligating the superior thyroids has been described in a preceding chapter on ligation of blood vessels. This is usually done under local anesthesia.

The technic of thyroidectomy, or partial thyroidectomy as it should more properly be called, for some of the thyroid tissue must always be left, is practically the same for goiters accompanied by hyperthyroidism as with the simple type, except that the former are as a rule, more vascular and smaller.

The operation is best done through the transverse collar incision of Kocher. In a symmetrical goiter this is made from one edge of the sternomastoid muscle to the other, about one inch above the sternum. The outer portion of the incision bends slightly upward. The incision, of course, has to be modified according to the shape and size of the goiter, and may be made higher or longer to render the thyroid more accessible. The flap is dissected to the larynx and the lower margin of the wound is freed to the sternum. The muscles of the neck are divided in the midline from the lower border of the larynx to just above the sternum and down to the true capsule of the thyroid gland, which is recognized by the large veins and vessels of the thyroid coursing within it. The goiter is thoroughly separated from the ribbon muscles of the neck by blunt dissection. Occasionally when the veins are large they may be ruptured and considerable hemorrhage will occur. If the separation is carefully done with the finger, and the proper line of cleavage is obtained, hemorrhage is usually avoided. It is important to recognize the thin muscles of the neck, otherwise the muscles may be seriously injured and the dissection will not follow the capsule of the thyroid, so that it will be difficult or impossible to mobilize the goiter. Many goiters, particularly those of moderate size, can be delivered through this incision, but if difficulty is encountered the muscles are cut across after doubly clamping them with heavy Ochsner forceps in their upper portion, as advised by C. H. Mayo, in order not only that the line of incision in the muscle will be at a different level from that in the skin, but to preserve the nerve supply of the ribbon muscles which enters below (Fig. 345). The clamps should be close together and division so made that when the muscles are united by suture but one line of trauma remains. If the Ochsner forceps are placed at some distance from each other and the division made between them there will be three lines of trauma, two made by the forceps and one by the cut. If the forceps are placed side by side the injury made by them and the incision will be so close that the muscles which have usually

been stretched by the bulging of the goiter can be reunited by a continuous suture of catgut, which will include both lines of trauma made by the forceps. In this way a reef is taken in the overstretched muscles.

With increasing experience the surgeon finds less necessity for cross cutting the muscles, though in many instances it adds not only to the ease of the technic, but permits delivery of the goiter with much less trauma than would be necessary if simply the midline incision in the muscle was employed. After freeing the goiter from its surrounding tissue with the finger and delivering it into the wound, the upper pole is doubly clamped with stout Ochsner

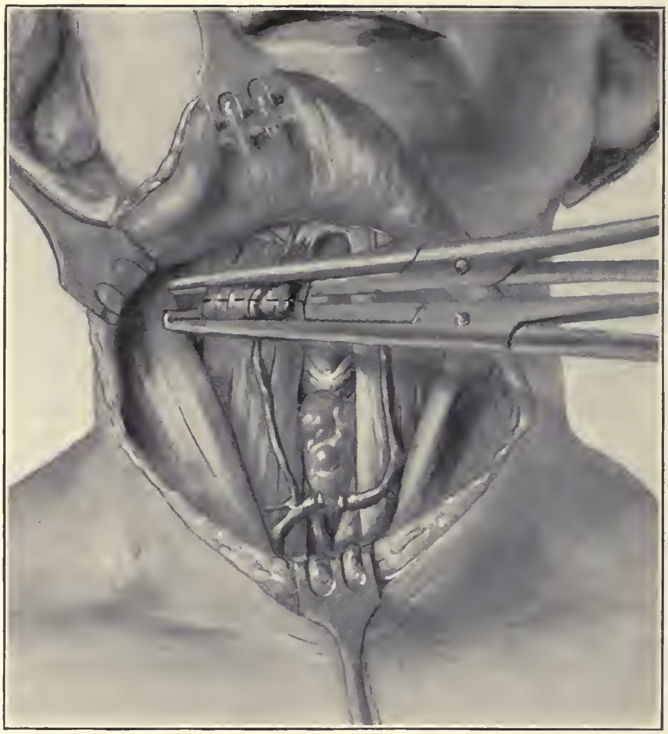

Fig. 345.—Exposure of goiter. The superficial muscles are clamped and are about to be divided.

forceps. The pole is well isolated and care taken to include all the branches of the superior thyroid in the grasp of the forceps. Many surgeons advise using three forceps, so placed that two will remain on the stump of the upper pole after its division, because it may retract and cause annoying hemorrhage. The tissue that is adherent to the goiter posteriorly is put on a stretch and any large vessels are clamped near the goiter (Fig. 346). After clamping and dividing the upper pole the dissection is carried from above downward, so releasing the lower pole. The posterior capsule of the goiter is left along with a small attached portion of thyroid tissue in order not to wound the recurrent laryngeal nerve. The trachea and thyroid are identified and an effort is made not to expose the trachea but to dissect close to the thyroid while removing it

from the trachea. In this way a thin layer of tissue is left over the trachea and small nerves in the tracheal wall, which might cause irritation if exposed, are protected by this layer of tissue. If the goiter extends on each side, dissection is carried across the midline and the goiter on the other side is well mobilized. The vessels are clamped first from above downward, taking care to leave some thyroid tissue at the upper pole and around the region of the entrance of the inferior thyroid artery, which will also protect the recurrent laryngeal nerve. The vessels are tied carefully with catgut. All oozing surfaces must be thoroughly controlled before closing the wound. If the raw

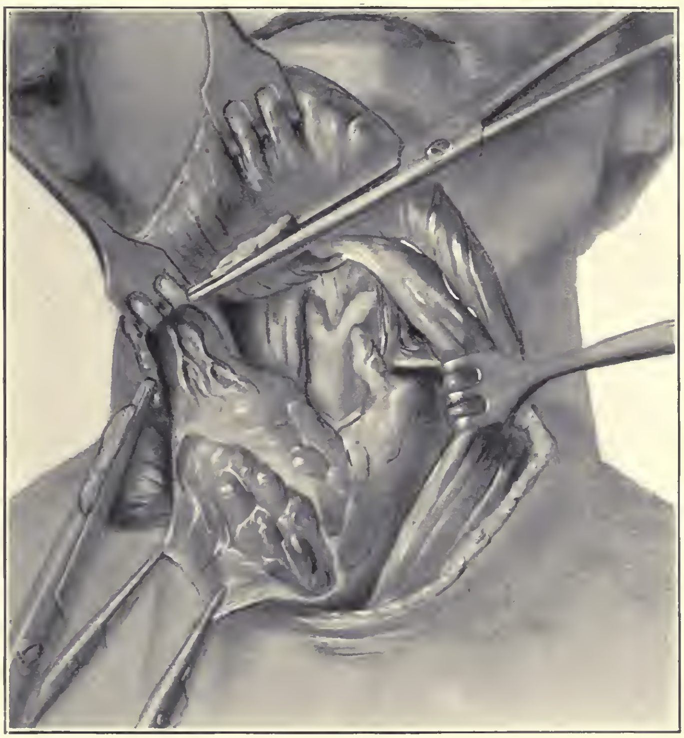

Fig. 346.—The goiter has been partially mobilized. The superior thyroid vessels are ready for clamping and division.

surfaces of the thyroid that are left continue to bleed they are whipped over with catgut. If the muscles have been cut across they are united by a continuous suture of plain catgut. The incision in the muscle in the midline is similarly sutured and a small drainage tube is inserted at the lowest end of the midline incision in the muscle. This appears to be necessary to prevent a large accumulation of serum that would otherwise occur.

The platysma and subcutaneous tissues are united by a continuous suture of fine plain catgut. The skin is brought together in two sections by a subcuticular suture of fine silkworm-gut. The tube, which is a very small one, protrudes from the middle of the incision. The continuous suture of each section

ends at the tube and when the tube is removed about the third or fourth day after operation the skin wound falls together without further suturing.

Sometimes the conformation of the goiter may be such as to make it wise to approach the growth from the midline. D. C. Balfour has described a technic in which this type of operation may be done. Willard Bartlett has special forceps for compressing the thyroid near its poles. The goiter is divided in the midline, dissected from the midline outward, clamped by forceps and excised in a wedge-shaped manner so that the raw surfaces in the goiter are approximated with continuous sutures which control the bleeding. Bartlett's technic does not necessarily include division in the midline, though in the operation described by him this may be done if it facilitates matters. He first clamps and divides the superior thyroid at the goiter and then compresses the vascular margin of the goiter with his forceps introduced from below.

CHAPTER XVIII

OPERATIONS ON THE UPPER EXTREMITIES

AMPUTATIONS

Amputations were formerly the glory of surgery because in preantiseptic days they were the chief operations that were performed. With the progress of surgery, however, efforts to save a limb instead of to destroy it, have been greater, so gradually amputation has come to be looked upon as a confession of failure to save the limb and of inability to conserve its function.

Amputation of the upper extremity or of a portion of the upper extremity may, however, be indicated either as a result of extreme trauma or of gangrene, infection, or malignant growths. Amputation for infection and trauma is done much less frequently than formerly because the modern treatment of wounds often succeeds in saving a limb even when infection is severe. The same is true of severe injuries. Probably the greatest contribution to military surgery during the World War was débridement, which is excising the injured tissue. If this is done a few hours after the wound is made or during the period of contamination before infection has set in, the raw surfaces may be sutured, or if that is impossible the wound may be treated as though it were a clean wound, and infection will seldom occur. After the first few hours, however, when the period of infection has begun and bacteria are multiplying in the tissues, débridement will merely expose freshly cut surfaces to the infective germs with which the tissues are infiltrated. Here, frequent dressings of antiseptics or treatment by the Carrel-Dakin method will often result in cure in cases that appear to admit only of amputation.

It must be borne in mind that it is much easier to amputate a limb than it is to save it, and while the patient's life should not be too greatly risked in order to save his limb, the operator should be reasonably sure that amputation is distinctly indicated before resorting to it.

In malignant growths amputation is not frequently justified. Bone cysts and so-called giant cell sarcomas can be treated conservatively by resection with bone grafting if necessary, or by thorough curetting and packing the cavity. If the growth is a periosteal sarcoma, amputation does but little good, for hardly more than four per cent of periosteal sarcomas are eventually saved by amputation.

In amputation there are certain general principles which should be discussed. Controlling hemorrhage is one of the chief problems. This becomes increasingly grave the nearer the site of amputation approaches the body. A tourniquet is the standard orthodox method of controlling hem-

orrhage and may usually be employed. It should be placed sufficiently far above the site of operation not to be in the way of the operator and preferably at some distance from a joint if it is a large joint. A tourniquet on the upper arm and thigh is more satisfactory than on the leg or forearm, because the presence of two bones in these latter regions sometimes prevents the action of the tourniquet from constricting the soft parts. It is best to place a towel next to the arm if a tourniquet is used so that the skin will not be injured. An excellent tourniquet is a broad thin rubber band, which is wrapped around a number of times and controlled by tying the ends together or by fastening with a clamp. A large, soft, black rubber tube also makes a good tourniquet and in amputation about the shoulder joint is superior to any other kind of tourniquet. In an emergency a handkerchief or a towel can be used very satisfactorily. After tying the handkerchief or towel tightly, a cane, or a long stick, is inserted just beneath the towel and twisted until sufficient pressure is obtained. A pair of suspenders makes an excellent tourniquet in an emergency.

In operations on the fingers or thumb a small soft rubber tube or a soft rubber catheter may be used for a tourniquet. An ordinary rubber band is a good tourniquet for the finger. If a soft rubber catheter is to be used, it is best applied by wrapping it once completely around the base of the finger and then carrying the ends across the back of the hand and around the wrist in a figure-of-eight turn and clamping the two ends together with a hemostatic forceps.

Tourniquets, however, are by no means free from danger. For this reason many industrial surgeons do not recommend them. A tourniquet may often be uselessly applied and if not tight enough will merely constrict the venous circulation and promote bleeding while if it is too tight actual damage may be done. The use of a tourniquet is also unwise in those cases in which the patient's resistance is at the lowest ebb, but in which amputation is clearly necessary because of gangrene. Here with low general vitality and impoverished circulation to the limb, particularly in arterial disease, the blood vessels may not only be injured by the application of the tourniquet, but the complete cutting off of nutrition from the tissues of the stump even for the short time that is necessary to perform the operation, has an injurious effect upon the resistance of these tissues and may embarrass the healing of the flap. In the presence of marked inflammation a tourniquet should be applied well above the inflammation, or if this is impossible it should not be applied at all.

The Esmarch method of controlling bleeding has largely fallen into disuse. This consists in beginning at the fingers with a rubber bandage and encircling the limb upward from the fingers, applying the bandage so snugly as to drive out all the blood. When the bandage reaches above the elbow a tourniquet is applied and then the Esmarch bandage is released. This method secures a bloodless field, but if amputation is done for infection the application of Esmarch's bandage would, of course, be exceedingly dangerous and would force into the circulation the products of the inflammation. Even in aseptic

injuries the aseptic products of injured tissues, which are now regarded as the chief cause of shock, may be dislodged and forced into the circulation in overwhelming amounts. In malignant diseases the Esmarch bandage would, of course, force cancerous cells into the circulation.

Before applying a tourniquet the limb should be elevated for a few minutes so that the venous blood that would naturally drain out of the limb because of gravity can be saved. If but little blood is lost during the amputation and the patient has not bled previously the total amount of blood in proportion to the tissues will probably not be changed, because with amputation of the extremity there is less tissue to be supplied with blood.

With a good knowledge of anatomy and a reasonably careful dissection even amputation at the shoulder-joint or at the hip-joint can be done without a tourniquet and with no large loss of blood, particularly in patients who are not very stout. A tourniquet in these regions, however, is as a rule, desirable. If a tourniquet is not to be used, the incision should be so shaped that the large vessels will be exposed at an early stage of the operation. They can then be doubly clamped, divided, and ligated and thus the main source of hemorrhage is controlled.

A good knowledge of anatomy is essential in amputating. The flaps should be cut as broad as possible so the nutrition will be abundant and the vessels should be ligated, preferably with catgut, before the tourniquet is removed. In amputations near the body where the vessels are large there should be two ligatures on the vessels, as recommended in the ligation in continuity. The ligature nearest the heart absorbs the impulse of the arterial current and makes the conditions of healing at the second ligature distally placed much better, as this second ligature is not subjected to the strain and impulse of the arterial current and the tissues it encircles are relatively at rest.

In amputations, particularly the larger amputations, it is best to use drainage. This may be removed after twenty-four or forty-eight hours in cases that are clean, but there is usually considerable outpour from the severed lymphatics, which, if not drained away, is absorbed with some difficulty by the tissues and interferes with the nutrition of the flaps, because it prevents them from coming in contact with raw surfaces having a good blood supply.

In amputation of the finger, drainage is not necessary. If it is felt that the stump is probably infected, or if the character of infection for which the amputation is done is highly virulent, the flaps may be either not sutured at all, or, better still, sutures of silkworm-gut can be placed but not tied and the flaps left open and packed loosely with iodoform gauze. As has been explained in the chapter on drainage, this will cause a reversal of the circulation of the lymph channels and so will prevent the absorption of much of the septic material that would otherwise be carried along the regular channels of the lymphatics toward the body. After five or six days if the tendency to infection has been overcome the gauze is loosened by soaking it in a mild antiseptic solution and by the application of peroxide of hydrogen. It can then be removed and the sutures tied.

The treatment of the bone in amputations involves a very definite procedure. If the amputation is through a joint, or in other words, is a disarticulation, care must be taken not to injure the cartilaginous coating of the joint. If the amputation is through the continuity of the bone the end of the bone is scraped out thoroughly with a curet, to remove the endosteum and the medulla, for a distance of about an inch. The periosteum is also removed from the external portion of the bone for about the same distance and the sharp margins are trimmed with forceps or with a coarse file. The method of using a periosteal flap in amputation has been discredited. While it is now known that the outer layers of the periosteal flap have nothing to do with regeneration of bone, the periosteum often promotes unnecessary callus and painful nodules; for when the periosteum is stripped up to make a flap small portions of the cortex of the bone and the cambium layer of the periosteum are removed and these cause deposits of bone at irregular points.

The so-called guillotine operation has been used in severe infections, or when there is great need for haste. In this method the limb is practically chopped off, all of the tissue being divided at about the same level. Naturally the muscles contract considerably and the bone protrudes. Often a secondary amputation has to be done later on. While indications for the guillotine amputation in the arm or forearm do not usually exist, it is sometimes a good procedure in amputating the finger where an effort is made to preserve as much of the finger as possible.

In every amputation the nerves should be cleanly divided with a sharp knife. The nerve should be pulled down and as much of it cut off as possible in order that the stump may retract and not be caught in the scar of the healing flaps, which is the frequent cause of painful stumps. The neuroma which forms on the end of a nerve after its section is usually not painful if there is no infection and if the scar tissue in the neuroma is not excessive.

One of the most unfortunate complications of the stump is a painful stump, which may be due to adhesions to the bone or to neuromas. Neuromas consist of connective tissue about the end of the nerve into which grow the neuraxes from the central portion of the nerve. If the end of the nerve is near the other scar tissue, or if there is considerable irritation, there is an abnormally large amount of scar tissue which produces a large neuroma that will almost certainly be painful. Huber and Dean Lewis have shown that if the last inch of a nerve be injected with alcohol at the time of amputation no neuroma will form, as the injection destroys the axones and does away with the tendency for them to grow downward into the end of the stump. This practice is simple and should be carried out.

While there are many types of amputations, there are general principles applying to them all which reduce the matter to the selection of that operation best fitted for the particular case. Often the character of an injury will make it necessary to modify the shape of the flaps. It must be borne in mind that the flap should be well nourished and not too long, and

particularly not too short, and if an artificial limb is to be worn the scar preferably should not be at the apex of the stump.

The amount of soft tissue necessary to cover a bone in amputation is, in the circular amputation, a distance of about three-fourths the diameter of the limb from the point of division of the bone to the end of the flap. This is equivalent to about one-fourth of the circumference of the limb. When a single flap or unequal flaps are used, the total length below the bone should be equivalent to about one and one-half times the diameter of the limb, which is one-half of the circumference, as the diameter is about one-third of the circumference. The skin and superficial fascia always contract considerably after incision, so full allowance should be made for this in any amputation. In amputating a large limb retraction is greater than in a small limb. It is better to have a flap a little too long than too short, because swelling makes tension and often contraction occurs later on. If, however, there is markedly redundant tissue it can be easily excised before the flap is sutured. In the lower part of the thigh and in the arm the tendency to retraction of the soft parts is very great and here flaps should be made equivalent to about twice the diameter of the limb or two-thirds of the circumference. In a circular amputation in this region the distance between the skin incision and the point of division of the bone should equal the diameter of the limb.

When an incision is made the skin is firmly grasped and retracted upward to make as much allowance as possible for the natural retraction. After the skin and fascia have been cut the muscles are incised. If a flap operation is made, as much fat and superficial fascia is turned back with the skin as possible in order to provide nutrition for the flap. If it is intended to use a muscular flap, the muscles are cut obliquely from without inward by dissection after the fascia has been incised. It is best, as a rule, to have a muscular covering for the bone.

A circular amputation is quickly done and has many advantages. It is applicable in the middle of the arm, of the forearm and of the thigh. The skin is divided circularly down through the fascia and is retracted, exposing the superficial muscles which are divided by a circular incision. This layer of muscles is retracted and the deep layer of muscles is divided at the level at which the bone is to be sawed. This makes a funnel shaped wound with the bone at the bottom and a satisfactory muscular covering. The skin has a maximum amount of nutrition as its vessels are not even interfered with by a longitudinal incision. Sometimes a cuff of skin and superficial fascia is rolled back in order to get a sufficient amount of covering. This is called the cuff operation and is merely a modification of the circular method.

The old method of transfixion with a long knife is but seldom used, the flaps now being dissected from without with a sharp scalpel. The chief objection to the transfixion method is that it often splits and divides vessels and nerves and makes their identification difficult and at the same time does not fashion the muscular flap as accurately as a careful dissection would.

Modifications of the circular and various forms of flap amputations are, of course, often necessary because the flap should be so fashioned as to secure the best nutrition, and as amputations are often done for injury it may frequently be necessary to do an atypical amputation in order to secure a satisfactory flap without sacrificing too much of the stump.

After the flaps have been cut an incision is made through the periosteum down to the bone, about half an inch above the desired point of section with the saw. In order to expose the bone the flaps are retracted by placing two towels over them snugly against the bone. Where there are two bones, as in the forearm and in the leg, three towels or three special pieces of cloth are necessary. After retracting the flaps the periosteum is divided with a circular incision and scraped down and the bone is divided about one-half an inch below the incision in the periosteum. The medulla and endosteum are carefully curetted away to about one-half an inch from the end of the bone. This makes a much better and a much less painful end of the bone than by using periosteal flaps. The vessels are identified, clamped, and carefully tied, preferably with catgut. The larger vessels are tied at two places about one-fourth inch from each other. If a tourniquet is used it is removed and other bleeding points are clamped and tied. If muscular covering is possible the muscle is sutured over the bone with interrupted sutures of catgut. The sutures are not tied tightly and no more are placed than necessary to obtain approximation. Sometimes the suturing of the fascial covering of the muscles brings the muscles into position. This fascia is sutured wherever possible. If there is redundant tissue either in the muscle or skin it is trimmed away but this ought not to be done until it is quite certain that the tissue cannot be utilized in the stump.

If a flap amputation is done the flaps are, if possible, so placed that a drainage tube in the angle of the flap will be at the most dependent portion. If a circular amputation is performed it should preferably be sutured in an anteroposterior direction so drainage can be inserted at the dependent portion of the wound. The skin is best closed with interrupted sutures of silk or silkworm-gut. The drainage tube of rubber is removed at the end of forty-eight hours if healing is satisfactory.

Besides the standard flaps and the circular method, other modifications are used, such as the racket incision, which is a circular or slightly oval incision combined with a straight vertical incision. The oval method of amputating is a modification of the circular in which the incision is made in an oval manner and brings the scar to the side of the stump instead of being at the apex. Elliptical amputation is practically the same as the oval, but is somewhat more inclined to the form of a flap and is chiefly used in amputations or disarticulations at the joints.

In amputation of the fingers or hand the palmar flap should always be longer because the skin of the palm is thick and bears usage better than the skin on the dorsal surface of the hand, and also because it is better nourished (Figs. 347 and 348). In amputation of the fingers a tourniquet may

be placed, as has already been described, using a rubber band, or a soft rubber catheter. As a rule it is best to amputate here through a joint. It must be borne in mind that the distal ends of the metacarpal bone of the phalanges form the knuckles so that the plane of the joint is distal to the knuckle, and the flaps should be shaped accordingly. The webs of the fingers are about three-quarters of an inch below the metacarpal joints. In planning an amputation of the finger the palmar flap should always be the longer wherever possible. It may be long enough to cover the whole stump and be united to the dorsal incision of the amputation, or there may be a short dorsal flap and a long palmar flap. The anatomy of the finger and the insertion of the flexor and extensor tendons should be borne in mind. The superficial flexors of the fingers are inserted into the sides of the middle phalanges and the deep flexors, after splitting the superficial flexors, are inserted into the bases of the last phalanges. The extensor tendons, however, are inserted along the whole of the back of the dorsal surfaces of the phalanges.

Where it is thought best to save as much of the finger as possible a

Fig. 347.—Line of incision for amputation of distal phalanx of finger.

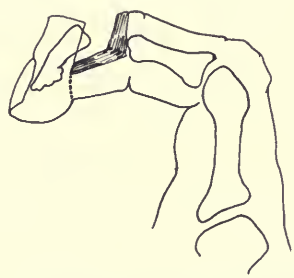

Fig. 348.—Showing the method of forming long palmar flap in amputation of finger.

guillotine operation can be done, dividing all the tissues at the same level. This, however, usually results in a painful stump. J. S. Davis, of Baltimore, has placed a celluloid ring around the stump, which appears to promote granulations and to give a thicker covering for the end of the bone than is obtained without this treatment. It is particularly desirable to save as much of the index finger and of the thumb as possible.

The flexor tendons of the thumb and of the little finger have a sheath that communicates with the large palmar synovial sac, and infection from these two points is more serious than would be infection from the other fingers. The flexor tendons, particularly of the index or little finger, should be attached to their sheath or to the periosteum by a few sutures when the sheath is opened so as to preserve the action of these tendons. The finger should be flexed when cutting the dorsal flap and extended when cutting the palmar flap. When an amputation is made through a joint as much as possible of the capsular ligament should be saved in order to cover the end of the bone (Fig. 349). In amputating through a joint, the joint is opened on the back first, cutting the extensor tendon, then dividing the lateral attachments, and

last of all cutting the flexor tendon. The tendons should be cut long enough to allow them to be reattached.

Amputation through the last phalanx should be done if possible by a single palmar flap. After outlining the flap with a knife the extensor tendon is cut and the joint opened on its back, as has just been described. The lateral attachments are cut and lastly the flexor tendon. The flexor tendon is fixed to its sheath or to the periosteum in its neighborhood by fine tanned or chromic catgut. After tying with catgut the digital arteries which are on the sides of the stump, the palmar flap is sutured to the dorsal flap by interrupted fine silk or fine silkworm-gut sutures.

If amputation is done through a joint, that is, if a disarticulation is done, it will require a longer flap to cover the bone than where the bone is divided. If it is impractical to take a long palmar flap, the flaps should at least be so fashioned that the palmar flap will be longer than the dorsal flap.

The same method is used in amputating the second phalanx. The flaps, as shown in the illustration, should not have sharp corners, but should be rounded. Occasionally it is necessary to take a flap from the lateral aspect of the finger instead of the palmar. This variation in the technic may be

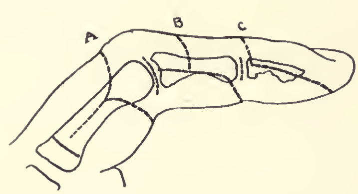

Fig. 349.—Amputation of the finger; *A*, through first phalanx by equal flaps; *B*, through first phalangeal joint by long palmar and short dorsal flaps; *C*, amputation by long palmar flap.

demanded by the situation of the lesion. The bone is divided with a saw, as bone forceps may splinter the bone.

Amputation or disarticulation of the finger at the metacarpophalangeal joint may be done by the oval or by the racket incision. The racket incision resembles a Y-shaped incision when looked at from the back of the hand (Fig. 350). It begins on the back of the metacarpal bone, a short distance proximal to its head, passes downward crossing the knuckle and then goes obliquely around the palmar aspect of the finger a short distance distal below the web of the finger. It is then carried around the other side of the finger in a symmetrical manner to the point of beginning. This may be made in two incisions, as in cutting a flap, so that the incisions diverge downward from the back of the knuckle. After the skin and fascia have been cut and are retracted the extensor tendon and then the capsular ligament are divided, saving as much of the ligament as possible. The flexor tendons are divided, as has been described, and are fastened to their sheaths with sutures. The digital arteries are tied. The wound is closed by suturing together the edges in an anteroposterior direction so that the scar forms a line leading from the back of the hand over the head of the metacarpal

bone to the palmar surface. The flap method can also be used here, particularly in the thumb, the index and the little fingers, but the oval or racket method is best in the middle and ring fingers. If it is desired to make the hand smaller, the head of the metacarpal bone may be excised, as its presence adds prominence to the defect because it accentuates the empty space, but it gives considerably more strength to the hand.

Amputation or disarticulation of several fingers with a portion or all of the metacarpal bones is done by a circular or oval incision. This may be converted into a flap method or into a racket incision by a single longitudinal incision. Amputation at the wrist joint should not be done if amputation at the carpometacarpal joint is possible. (Figs. 351, 352.) Amputation of a single finger

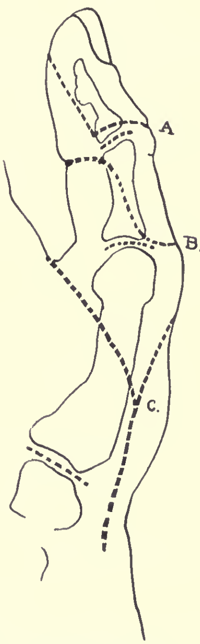

Fig. 350.—*A*, amputation of last phalanx by palmar flap; *B*, amputation of thumb at the proximal joint by long palmar flap; *C*, disarticulation of first metacarpal bone and thumb by oval method.

with its adjoining metacarpal bone is done by a circular or an oval incision around the base of the finger through the webs of the finger which is joined by a straight incision over the back of the metacarpal bone through its whole length. If the ring or middle fingers are infected often disarticulation of the corresponding metacarpal bone adds symmetry to the hand but at the expense of strength.

Amputation at the wrist, if done with a palmar flap is begun with an incision starting about half an inch below the styloid process of the radius. It is carried down and across the palm of the hand about the middle of the metacarpal bones and ends one-half inch below the styloid process of the ulna. The incision on the back of the wrist curves slightly upward

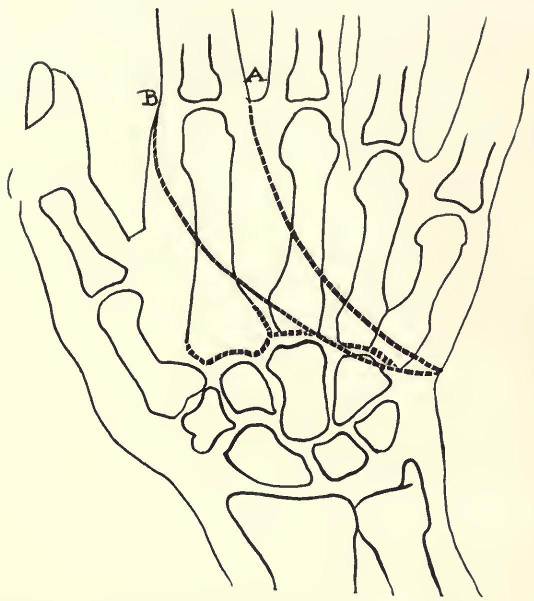

Fig. 351.—*A,* disarticulation of the third, fourth, and fifth metacarpal bones; *B,* disarticulation of all metacarpal bones except the thumb.

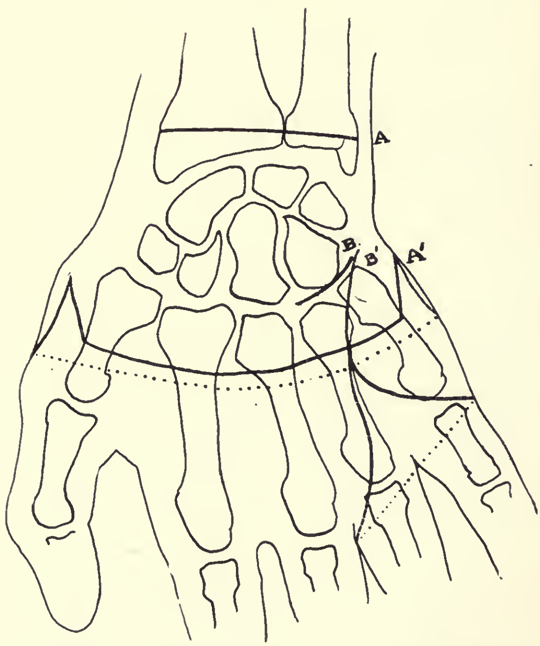

Fig. 352.—*A* and *A',* amputation of the hand at wrist joint by equal flaps. *B,* disarticulation of third and fourth metacarpal bones.

so that the palmar flap covers well the whole of the stump. The dorsal incision is carried down to the bone and the tissues are dissected as far as the joint. The long tendons are divided either at the extreme level of the incision to allow them to retract or, if a motor stump is planned, they are made long and the extensor tendons are united to the flexor tendons across the ends of the bone after the joint has been divided. After completing the disarticulation of the joint the palmar flap is turned back and sutured to the dorsal flap. Drainage is provided for the first forty-eight hours.

If impossible to secure a long palmar flap at the wrist a double flap can be used, making the palmar flap and the dorsal flap of about equal length. Great care should be taken to see that the flaps are not too narrow. (Fig. 352.) Sometimes flaps may be secured from the side, either from the radial or ulnar side, depending upon the emergency of the situation.

Amputation of the forearm can usually be satisfactorily done either by the circular method or by an anterior and posterior flap, as has been described. In the lower third of the forearm the circular or cuff method is good or a double flap may be used. In the upper two-thirds of the forearm the circular method or equal flaps are satisfactory. The muscle can best be cut in two layers, superficial and deep. Particular care must be taken to see that the median, radial, ulnar, and interosseous nerves are identified, injected with alcohol and divided as high as possible, so that they will not form attachments to the scar of the stump (Fig. 353).

A motor stump, or a cineplastic, amputation may be done through the forearm. Here a double motor stump is made. The circular incision through the skin and subcutaneous fascia is made as low down on the forearm as possible, and the muscles and tendons are divided to the bone at a level with the retracted skin. Vertical incisions are made on the radial and on the ulnar side down to the bone extending up from the circular skin incision about six inches. In this manner an anterior and a posterior flap are formed and are dissected up so that each flap contains all the tendons, muscles and other tissues between the skin and the bone. The radius and ulna are divided at the upper end of the vertical incisions. In this manner one flap contains the extensor tendons and the other the flexor tendons. The skin and fascia are freed from the muscle of the flap for about half the length of the flap and the tendons in each flap are divided into two groups. Each group is sewed together so as to make a loop. The skin of each flap is then sutured over the flap to cover the bundles of tendons, and a longitudinal incision is made in the skin of the flap opposite the loop of the tendons. A second incision is made in the folded over skin opposite the first incision. These button-hole incisions are about one inch long.

A similar procedure is carried out with each flap. In this manner the anterior flap contains the flexor tendons and the posterior contains the extensor tendons. In each of these two flaps the long tendons, which have been sewed together in a loop, surround a perforation that is made in the skin covering the flaps. A rubber tube is placed through the perforation in the

anterior flap and another rubber tube in the posterior flap. No traction is made upon these tubes for about ten or twelve days when gradual traction is begun. The patient can voluntarily move the anterior or flexor flap or the posterior or extensor flap. An apparatus fitted over the forearm and connected with these flaps in front and behind can be worked voluntarily by cords running from the flaps to the fingers of the artificial hand.

A motor or cineplastic stump can also be constructed by having the group of anterior flexor tendons attached to a piece of bone, as to the end of the radius, and the posterior or extensor tendons to the end of the ulna. About two inches of the bone is resected, just proximal to the end, leaving the

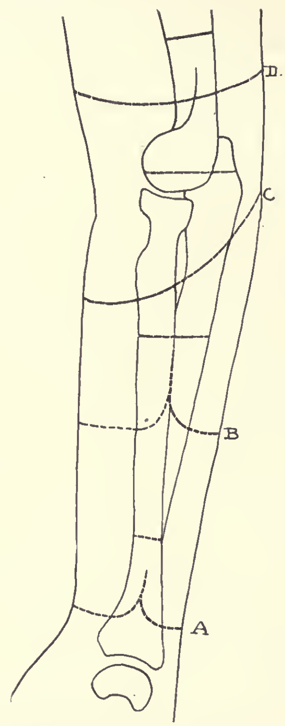

Fig. 353.—Lines of incision for amputation of forearm; *A*, by cuff method; *B*, by equal flaps; *C*, by oblique circular method; *D*, by circular method.

ends of the radius and ulna unconnected. A slight constriction is placed on the stump behind the ends of the bones and when healing takes place a ring is fitted, which is capable of transmitting motion to an appliance that is connected with it. This works on the same principle as the perforated cineplastic flap.

If there is infection the cineplastic amputation should not be attempted, but all of the tendons and muscles of the stump should be saved and after healing has occurred and infection has been overcome the cineplastic amputation may be done.

Cineplastic amputations producing a motor stump have been used in

Italy, but the method has not been widely adopted. It apparently has not been satisfactory in America. It requires very considerable sacrifice of the bone in order to produce the motor stump and consequently greatly shortens the stump. The flaps are difficult to keep in good condition, but the most important objection seems to be that it is difficult to obtain in America the proper apparatus to be applied and, of course, without the proper apparatus the cineplastic stump is of no more value than the simpler amputation. If attempted in amputation above the elbow the same principle would be adopted as in the forearm.

In any amputation about the arm or forearm as much tissue as possible should always be saved. An effort should be made to provide a stump as nearly ideal as it can be made. This means that the scar should be linear, should not be adherent to the bone, and should not have too much redundant tissue. In amputation about the hand every effort must be made to preserve as much of the hand, and particularly of the fingers, as possible. To leave one finger, however, when the tendons are destroyed is doubtful wisdom, as it becomes ankylosed and painful and better service may often be obtained by providing a hook or some similar device that can be attached to the end of an artificial arm. The stump of the forearm is valuable for leverage and should be left long except that, when the bones of the carpus are seriously injured, it may be better to amputate at the wrist joint than through the carpus or at the carpometacarpal junction.

If the bones in the stump of the forearm measure less than three inches from the tip of the olecranon it will be difficult or impossible to adjust a satisfactory artificial arm, though if it is contemplated not to use an artificial arm even so short a stump is of considerable service. The possibility of the use of an artificial arm must always be borne in mind when amputating in the arm or forearm, though many patients do not wear artificial arms, whereas after amputation in the lower extremity an artificial leg is always most desirable. An amputation through the elbow is difficult to fit with an artificial arm, so if an artificial arm is contemplated and a satisfactory stump cannot be secured from the forearm, it will be better to amputate about one inch above the condyles of the humerus.

In amputation of the forearm the stump should be as long as possible. The anatomy of the parts must be borne in mind as in operations elsewhere. The main nerves of the forearm, which are the median, the ulnar, the interosseous, and the radial, should be identified as well as the arteries. The relations of these structures to the muscles vary at different levels of the forearm.

Amputation at the elbow may be done by any operation that permits satisfactory covering of the end of the bone. It must be recalled that amputation or disarticulation through the elbow is not satisfactory if an artificial arm is to be worn, and also that the end of the humerus requires a large flap of skin to cover it satisfactorily. The anatomical structures of importance about the elbow are important. The largest artery is the brachial,

with the superior and inferior profunda, and the anastomotica magna. The flaps will usually contain the radial with its recurrent branch and the ulnar with its recurrent branches. The position of the ulnar nerve, the musculo-spiral, and the median, the last of which lies internal to the brachial artery at the elbow joint, must be borne in mind.

Probably the most satisfactory method of amputation at the elbow is the elliptical, or oblique circular, method; though a long posterior flap and a short anterior flap make a satisfactory amputation as the skin on the back of the forearm is thicker and tougher than the skin on the front of the forearm. The necessities of the occasion, however, may demand a longer flap from the front of the forearm or an external and an internal flap.

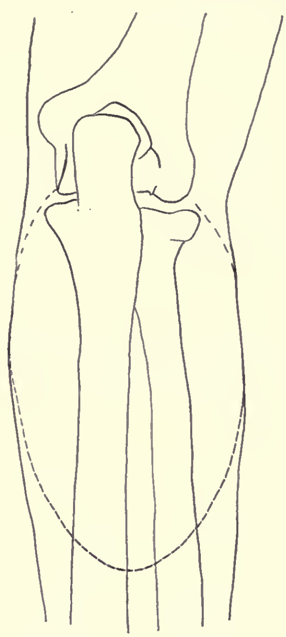

Fig. 354.—Lines of incision for amputation at elbow by posterior elliptical flap.

If the amputation is to be done by the elliptical method, this is begun by marking out the skin flap and making the upper limit anteriorly about opposite the condyles (Fig. 354). The lower limit is posterior and about one and one-half diameters of the arm below the condyle, that is, about one-half of the circumference of the arm. The flap is about four inches long in the average case. The incision is begun with an ordinary scalpel at the upper limit with the joint flexed at a right angle and passes down the inner side of the joint and obliquely down to the lower limit, then upward on the outer portion of the limb to the point of beginning. The skin and fascia are cut through and when retraction has occurred the muscles are divided on the line of the retracted flap. The posterior muscles are dissected free from the bone and when the dissection has reached the ligaments of the joint the ligaments are

divided and left attached to the muscle. Disarticulation is completed by an incision in front and the posterior muscle flap is turned forward and sutured over the articular surface. The skin flap is then separately sutured. The convex lower end of the flap is fitted into concave upper part of the ellipse. If the disarticulation is done by a long posterior and a short anterior flap the incisions are marked out beginning about an inch below the condyles. The posterior flap is shaped by carrying the incision down and then backward across the back of the forearm. This joins a similar incision on the other side. The anterior flap is about one-half the length of the posterior flap. The length of both flaps is equal to about one-half the circumference of the arm at the condyles. The fascia is incised and allowed to retract and the muscles are cut on the level of the retracted flap. They are dissected from the bone

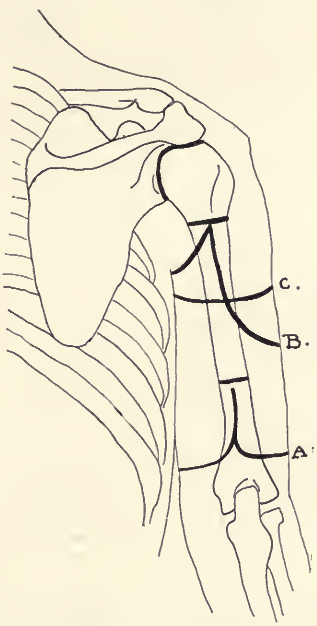

Fig. 355.—Lines of incision for amputation of the arm: *A*, by lateral flaps; *B*, by long external flap; *C*, by circular method.

up to the ligaments of the joint and the ligaments are divided as in amputation by an ellipse. As much of the ligaments as possible is left attached to the muscle flap. This is a rule in amputation at any joint. The ligaments of the head of the radius are divided behind as the elbow is flexed, and in this manner the joint is opened. The capsule of the joint is divided around the olecranon and the elbow is then extended and division completed anteriorly. After tying the vessels the muscles are sutured over the joint and the skin is closed as in amputation by the ellipse.

Amputation of the arm may be done at any level but if an artificial arm is to be employed the stump should be not longer than results from the section of bone about one inch above the condyles (Fig. 355). Every

inch of good stump that can be saved above this adds to the strength of the stump and makes the artificial arm more efficient. The anatomy of the arm must be thoroughly considered before undertaking an amputation. At the upper part of the arm all the important cords and vessels are on the inner portion of the arm. The musculospiral nerve about the middle of the arm is closely connected with the humerus, and it is particularly important to guard against the possibility of the stump of this nerve being involved in the healing of the bone after amputation. This nerve should be identified, pulled down, injected with alcohol, and divided so that it may retract. This treatment, of course, should be given all nerves that can be recognized but it is particularly important in the musculospiral.

Amputation in the lower third of the arm may be done satisfactorily with the circular method, or any form or shape of flap can be used that suits the emergencies of the situation. An external and internal flap give better drainage. If the circular method is used it is done as recommended for other circular methods and the wound is sutured anterior-posteriorly in order to secure satisfactory drainage. The modified circular method with short flaps or a short anterior and a long posterior flap may be used. If flaps are used they are so fashioned as to provide satisfactory covering for the stump. All the nerves must be treated as mentioned for the musculospiral.

Amputation of the middle third of the arm may be done with flaps that are equal or unequal. Usually a long anterior and a short posterior flap are used. The flaps should be equal in length to one-half the circumference of the limb and the anterior flap is twice the length of the posterior. The brachial artery should lie in the anterior flap. It is highly important that the nerves be identified and properly treated.

Amputation of the upper third of the arm is best done by a single external flap, though anterior and posterior flaps may be used. If the external flap method is adopted the vertical incisions are begun at opposite points, anterior and posterior, and are about an inch below the point of division of the bone. These incisions pass downward and curve to a point on the outer side of the arm so that the flap is equal in length to the diameter of the limb, which is a third of the circumference. An inner incision connecting the upper ends of the two vertical incisions is made and passes obliquely downward and inward on the portion of the arm next to the thorax. It is best to save the tendon of the major pectoralis muscle. If the bone is to be divided above its insertion, the periosteum with the insertion of this tendon is stripped up and left in the flap and is sutured to structures on the outer or front side of the stump of the bone. The tendons of the latissimus dorsi and the teres major muscles are also preserved if possible. The circumflex nerve and the posterior circumflex artery are kept from injury by making the incision along the thorax side of the arm low down. After the muscles have been divided to the bone the outer flap is retracted and then the soft parts of the inner portion of the arm are also retracted to expose the

bone. A malleable retractor is placed internally in order to protect the vessels while the bone is being sawed.

Amputation or disarticulation at the shoulder joint can be done by the external racket incision of Larrey, by the anterior racket incision of Spence, or by the U-shaped flap. The great problem in all of these operations is the control of hemorrhage. The difficulty with a tourniquet lies in the fact that a tourniquet will slip after disarticulation at the shoulder by any operation unless it is fastened by some special method. Sometimes preliminary liga-

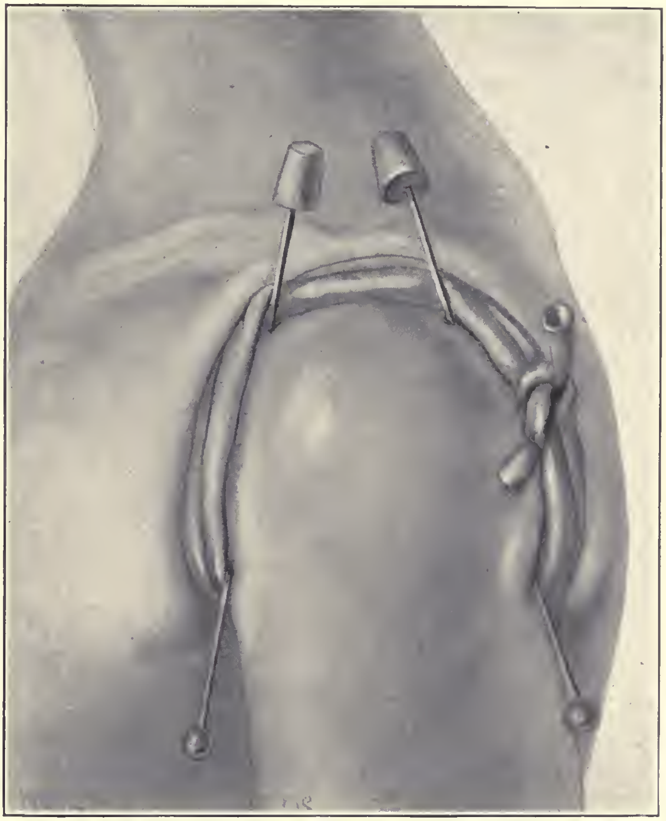

Fig. 356.—Wyeth's method of hemostasis for amputation at shoulder.

tion of the subclavian artery is advisable if the amputation is done because of a tumor that encroaches upon the joint and makes the application of a tourniquet so near the lines of incision that too small a margin of healthy tissue will be left. If the metal pins of Wyeth are used to hold the tourniquet in position the anterior pin enters at the middle of the lower margin of the anterior axillary fold and emerges about an inch internal to the tip of the acromion process. The posterior pin enters the corresponding point on the posterior axillary fold and emerges posterior to the first pin and about the same distance internal to the tip of the acromion process. A large soft

rubber tube is wrapped around the shoulder internal to the pins after the tips of the pins have been protected by cork to prevent injury to the operator's hands. The tube is wrapped around tightly four or five times and securely fastened by tying the ends with a bandage, and also by a stout clamp. The ends are placed posteriorly so they will be out of the way during the manipulation of securing the vessels and severing the nerves, which are at the anterior and inner portion of the upper arm (Fig. 356).

If the external racket method is to be used the incision begins just below and in front of the acromion process and is carried down vertically on the outer surface of the arm for about four inches. From the center of this incision an oval incision is begun which is carried around the arm downward and then upward in such a manner that the lowest point of the oval

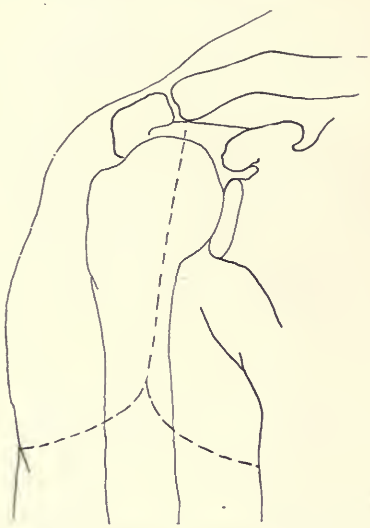

Fig. 357.—Lines of incision for amputation of shoulder by anterior racket method of Spence.

incision is on a level with the lowest end of the vertical incision. The oval incision is carried only through the skin and subcutaneous tissue at first. The anterior structures are then divided down to the bone and after this the posterior structures. The capsule is cut over the head of the bone and the arm rotated outward when the tendon of the subscapular muscle is cut. After this the arm is rotated inward and the supraspinatus, the infraspinatus and the teres minor muscles are divided. The rest of the capsule of the joint and the ligaments are divided, saving as much of these structures for the flap as possible. The axillary artery is doubly ligated with catgut and the nerves are treated in the usual manner, being injected with alcohol. All vessels are clamped and tied and the tourniquet is gradually loosened to see if any bleeding vessels have escaped. The muscles and fascia are sutured together and the skin is closed in the usual manner.

The anterior racket incision (Fig. 357) is done by a vertical incision

which begins at the level of the upper portion of the head of the humerus between the coracoid and acromion processes and passes down through the deltoid and major pectoral muscle to the insertion of the major pectoral muscle, which is divided. Here the incision branches and one passes downward and inward and the other downward and outward, forming an oblique incision and surrounding the arm about on a level with the insertion of the deltoid muscle. The vertical part of the incision exposes the joint and the bone. The muscles are cut on a level with the retracted skin and fascia, dissecting up the inner portion of the flap toward the axilla first. The outer portion of the incision, which divides the deltoid muscle just above its insertion, is then carried down to the bone, taking care to avoid the circumflex nerve to the deltoid, by making the outer limb of the incision as low as the insertion of the deltoid muscle. This incision is then carried down to the bone and the muscles are separated from the bone by periosteal elevators. Much of this can be done through the vertical incision by rotating the arm first inward and then outward. The muscles inserted into the head of the humerus are divided and as much of the capsule of the joint is preserved as possible. After securing the vessels and treating the nerves the stumps of the muscles are sutured together to protect the acromion process and the glenoid cavity.

Amputation through the shoulder joint may also be done by inner or outer flaps or by other combinations that may appear advisable under the circumstances. Crile makes an incision along the outer margin of the sternomastoid just above the clavicle, divides the deep fascia, retracts the omohyoid downward and the trapezius muscle backward, and exposes the trunks of the brachial plexus and also the subclavian artery. The trunks of the brachial plexus are injected with novocaine or with cocaine. A clamp whose blades are protected with rubber is applied to the subclavian artery. Amputation is then carried out without a tourniquet, according to any of the methods that may seem desirable.

Amputation of the complete upper extremity, or interscapulothoracic amputation, is occasionally indicated. The method of LeConte is satisfactory. The incision begins at the inner end of the clavicle and is carried along the bone to its middle, then curves downward to the anterior axillary fold. The skin and superficial fascia are dissected exposing the inner two-thirds of the clavicle. The clavicle is disjointed from its attachment to the sternum and the sternomastoid muscle is divided where it is inserted into this bone. The clavicular portion of the pectoralis major is separated bluntly from the costal portion of the muscle as far as the anterior axillary fold. The clavicle is pulled upward and forward and the subclavius muscle, which is put on a stretch, is divided at the first rib. The pectoralis minor is next divided and its outer portion reflected up with the clavicle. The axilla and its vessels are fully exposed. The sheath of the vessels is opened, the vein separated from the artery, and two ligatures are passed around the artery. The arm is then held up to empty the blood into the veins as much as possi-

ble and two ligatures are placed on the vein. If the cephalic vein enters the axillary vein above the point of ligature it will also require a ligature. The vessels and the brachial plexus are divided. The costal portion of the pecto ralis major is severed, which completes the division of the anterior attachments of the arm. The posterior incision is then carried from some point on the anterior incision, as near the tumor as it is thought safe to go, backward and downward to the lower angle of the scapula and then to the posterior axillary fold. The skin and fascia are dissected for a short distance, the trapezius muscle is divided, and the transversalis coli and the posterior scapular arteries are secured and divided. The muscles attached to the inner border of the scapula are divided close to the bone, the seratus magnus muscle is severed, and the latissimus dorsi is divided at the posterior axillary fold. The arm is now held to the body only by the skin of the axilla. If there is enough flap to cover the wound the anterior and posterior incisions may be sutured over the axilla, but if more skin is needed a flap should be fashioned from the under surface of the arm with its base at the axilla before completing the amputation. The skin and the superficial fascia are united in the usual manner and a drain is inserted at the lowest angle. No effort is made to suture the muscles.

Crile advises dividing the clavicle and resecting the inner half of the bone to expose the subclavian vessels and the brachial plexus. He then injects the brachial plexus with cocaine, or novocaine, ligates the subclavian artery and then the subclavian vein. The rest of the operation may be completed according to the method of LeConte.

The chief advantage of the method of LeConte is in exposing the subclavian artery and vein so that the artery can be readily tied before the vein is divided. In this manner much loss of blood is prevented.

EXCISIONS

Excision of the wrist joint may be partial or complete. In partial excision the region to be excised is exposed by an incision that injures the tendons, vessels, and nerves as little as possible. In complete excision the operation may be done by a single dorsal incision, by two dorsal incisions, or by two bilateral incisions. The styloid processes of the radius and ulna and the base of the second metacarpal bone are identified. When a single dorsal incision is used it is placed along the outer border of the extensor indicis tendon. The incision is about four inches long and begins over the lower end of the radius and ends about the middle of the second metacarpal bone. The dorsal structures are freed while extending the wrist to relax the extensor tendons. The bones of the wrist may be excised subperiosteally through this incision by making strong retraction. When the structures are large and the tendons strong two dorsal incisions are more satisfactory. Here a radial incision starts over the lower end of the radius about half way between the styloid process of the ulna and the styloid process of the radius. The

incision is carried obliquely downward to the outer side of the middle of the second metacarpal bone. The upper end of the incision may be prolonged on the forearm if it facilitates the operation. The tendon of the extensor indicis is retracted outward, thus exposing the metacarpal bones. The dorsal branch of the radial nerve must be protected. The posterior annular ligament is divided and the wrist joint is opened. The second incision begins about one and one-quarter inches above the tip of the styloid process of the ulna and goes downward to the base of the fifth metacarpal bone. It is on the outer side of the tendon of the extensor carpi ulnaris and exposes the ulna and the unciform bone. The dorsal branch of the ulnar nerve to the little finger must be avoided. The carpus is removed by stripping the bones from their ligaments and periosteum and removing them with forceps or a curet. The ends of the radius and ulna can be removed by pushing them through the wound, stripping back the periosteum, and sawing off the diseased portion. Drainage tubes are inserted and the hand is put in a splint.

Bilateral incisions are sometimes used for excision of the wrist joint. Here the outer incision begins at the middle of the lower end of the radius about on a level with the base of its styloid process. The incision goes downward and outward, parallel with the tendon of the extensor longus pollicis to the inner side of the first carpometacarpal articulation. From this point it is carried down the outer side of the second metacarpal bone to the middle of this bone. This incision is four inches long. The radial artery should be avoided. The incision will divide the insertion of the tendon of the extensor carpi radialis muscle but no other tendons. The soft tissues on the ulnar side of the incision are dissected while the wrist is extended. The trapezium bone is not removed until last and should be left unless its removal is necessary. The second lateral incision, about two inches long, begins at the lower front end of the ulna and goes down between the bone and the tendon of the flexor carpi ulnaris as far as the middle of the fifth metacarpal bone on its palmar surface. The inner side of the wound is retracted and the insertion of the tendon of the extensor carpi ulnaris is cut. The posterior soft tissues are dissected from the bone while the wrist is strongly extended. The posterior ligaments are divided, though the connection of the tendons with the radius is left (Fig. 358).

In excisions by any method it is wise to remove diseased bone and leave healthy bone wherever possible even though a typical operation cannot be done.

Excision of the elbow may be performed for active disease or for ankylosis. In the presence of active disease the pathology is removed as thoroughly as seems necessary. When the operation is for ankylosis a more typical procedure can be followed. One type of operation, however, cannot well meet all indications. By whatever method of approach the operation is done, an effort should be made to remove no more bone than is necessary and it must always be borne in mind that a stiff elbow joint ankylosed at an angle is preferable to a flail joint (Fig. 359).

In the typical operation the humerus is sawed through at its epicondyle, the ulna at the base of the coronoid process, and the radius at its neck. Sometimes more bone than this must be sacrificed. Sometimes much of the olecranon can be saved and this is always desirable, as it contains the insertion of the triceps muscle. The insertion of the brachialis anticus muscle in the ulna and the biceps in the radius should be preserved if possible. The posterior part of the joint is subcutaneous. All of the important vessels and nerves lie in front of the joint, except the ulnar nerve, which must be carefully protected, particularly that portion which lies behind the inner condyle of the humerus and along the inner side of the olecranon.

Excision may be done by a long posterior incision, by a lateral incision on the radial side, or by a right-angle incision. After the operation the arm is put in a splint with the elbow slightly flexed. Extension can be placed upon the forearm by boards in a plaster of Paris case. Adhesive plaster

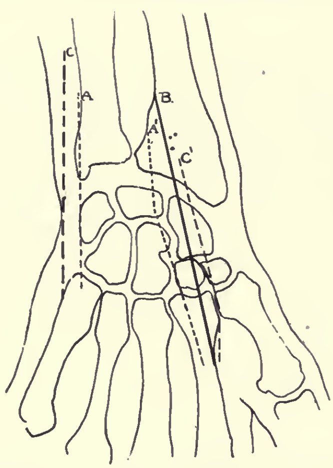

Fig. 358.—Lines of incision for excision of the wrist: *A* and *A'*, two dorsal incisions (Ollier); *B*, single dorsal incision of Boeckel; *C* and *C'* bilateral incisions of Lister.

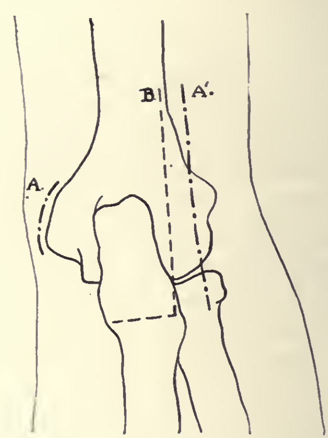

Fig. 359.—Lines of incision for excision of elbow: *A* and *A'*, long external and short internal incisions; *B*, a right angle incision.

strips are first applied to the forearm in somewhat the same manner as is used on the leg in Buck's extension. These are connected by elastic tubes to a cross piece over the ends of the boards as they protrude beyond the hand. This apparatus is removed at the end of two weeks and passive motion is begun (p. 167).

When the radial, or bayonet incision of Ollier, is made the upper arm is placed in a vertical position with the forearm slightly flexed. The incision begins about two inches above the upper portion of the olecranon in the space between the supinator longus and the triceps about one and one-quarter inches above the external epicondyle. The incision is carried downward parallel with the humerus to the epicondyle and then downward and inward to about the middle of the outer side of the olecranon. From this point it goes over the back of the olecranon and downward for about two inches.

On account of its shape it is often called the bayonet incision. The triceps on the inner side is separated from the muscles on its outer side and the capsule of the joint is exposed and opened. The periosteum and capsular ligaments are divided at the outer edge of the articular surface and the attachments of the muscles are raised with a periosteal elevator. The periosteum of the ulna with the tendon of the triceps is raised from the other edge of the articular surface. The external condyle of the humerus is denuded and the periosteum and muscular and ligamentous attachments are raised. The elbow joint is flexed and the lower end of the humerus protrudes into the wound. The periosteum is completely separated and the lower end of the bone is sawed off. The head of the radius and the ulna are also removed.

The posterior median incision has been a very popular one for excision of the elbow joint. It is about four inches long and is in the direction of the long axis of the forearm. It begins two inches below the tip of the olecranon process, passes over the posterior border of the ulna upward and across the center of the olecranon, splits the triceps tendon and is carried down to the bone. The joint is opened and the parts are retracted, taking particular care to protect the ulnar nerve on the inner side of the olecranon and ulna. The periosteum is divided over the humerus and stripped up, keeping close to the bone. The ligaments are raised in the same manner. The tissues on the outer side are also separated from the bone until the outer condyle is reached. The posterior interosseous nerve must be avoided in this region. The joint is strongly flexed and the lower end of the humerus protrudes through the wound. The bone is sawed in the usual manner.

Excision by a right angle incision is done by beginning a longitudinal incision three inches long on the outer side of the joint about one and one-half inches above the tip of the olecranon. This is carried down behind the outer condyle at a point just behind the neck of the radius. A second incision is carried inward at a right angle and crosses back of the ulna. This triangular flap with the periosteum of the ulna is dissected, the external ligaments are divided, and the head of the radius is removed. Then the ulna is exposed and sawed across and the humerus finally is dislocated into the wound.

After any of these operations, muscles or fascia may be interposed between the ends of the bones. A flap of fascia or muscle from the brachialis anticus or from the anconeus may be taken. A strip of fascia lata from the leg may also be utilized. This is fitted over the lower end of the humerus as a hood or cap with the fatty surface toward the joint.

In any excision of the elbow enough bone should be removed to permit the hand of that side readily to be carried to the opposite shoulder after the interposition of fascia.

Excision of the shoulder joint usually requires the removal only of the head of the humerus, though sometimes it may be necessary to remove the glenoid cavity also. The excision may be done through the anterior incision of Ollier, through the vertical incision of Langenbeck, or through the curved

flap incision of Senn. (Fig. 360.) It may also be done through a posterior approach, according to the method of Kocher.

The anterior incision is about four inches long and begins at the outer side of the tip of the coracoid process and passes downward and slightly outward along the anterior margin of the deltoid muscle. The capsular ligament is opened to the outer side of the tendon of the long head of the biceps. The periosteum and the capsular ligaments are raised from the bone with a periosteal elevator as far outward as possible while the arm is rotated inward. The insertion of the muscles into the greater tuberosity is raised along with the periosteum. This may be done by a periosteal elevator or with a chisel if the condition of the bone permits. The tendon of the biceps

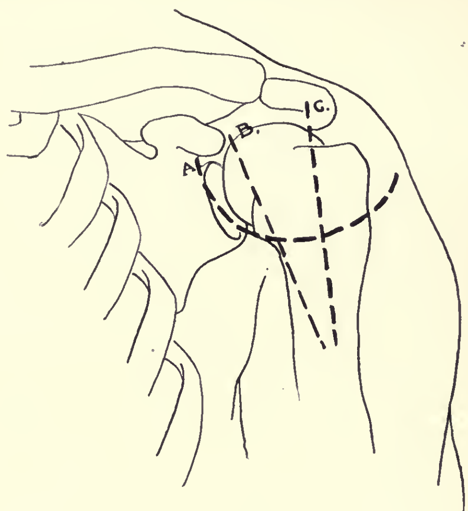

Fig. 360.—Lines of incision for excision of the shoulder joint; *A*, curved incision of Senn; *B*, anterior incision of Ollier; *C*, vertical incision of Langenbeck.

is retracted outward, and the periosteum is elevated toward the axilla. The head of the humerus is dislocated through the wound, the periosteum of the posterior surface is completely elevated and the head of the bone is sawed off. Drainage is best made by a posterior stab wound.

In the vertical incision of Langenbeck the arm is rotated inward and the incision begins at the anterior border of the acromion process and goes down about four inches in the line of the bicipital groove. The incision splits the deltoid muscle to the tendon of the biceps. The sheath of this tendon is divided, the tendon retracted, and the joint opened through the posterior portion of the sheath. The periosteum and capsular ligament of the joint are elevated while first rotating the arm outward and then inward. The bone is removed as in the previous operation. This operation has not the advantages of the preceding one because the incision is deeper and some of the nerve supply to the deltoid is destroyed.

Senn practiced approach to the shoulder joint by raising a large U-shaped

flap with its base over the shoulder joint and consisting largely of the deltoid muscle. This gives an excellent exposure but divides the deltoid and makes an extensive wound.

Excision of the shoulder joint can be done posteriorly by the method of Kocher. This incision begins at the acromioclavicular joint, goes backward along the acromion and spine of the scapula, dividing the trapezius muscle. From about the middle of the spine of the scapula the incision is carried downward toward the posterior fold of the axilla ending about one and a half inches from the lower border of this fold. The infraspinatus and supraspinatus muscles are separated from the acromion and the acromion process is divided with a saw or chisel about where it joins the spine of the scapula. Holes are drilled in the bone for future suturing before it is divided. The acromion with the deltoid muscle attached is retracted over the head of the humerus. The joint is opened along the line of the bicipital tendon, which

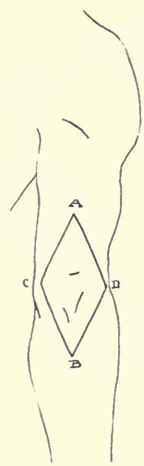

Fig. 361.—Lines of incision for removal of diamond-shaped area at elbow.

is retracted forward as the external rotators are retracted backward. The head of the bone is thus readily exposed and when the operation is completed the acromion is sutured to the spinous process of the scapula.

ARTHRODESIS OF THE ELBOW

The operation for immobilizing the joints, arthrodesis, is but seldom indicated in the joints of the upper extremity. Occasionally it is needed to fix the elbow joint. This is best done by the procedure of Sir Robert Jones. A diamond-shaped area of skin is excised (Fig. 361). The upper extremity of the diamond-shaped incision is at the junction of the middle and lower thirds on the anterior surface of the arm. The lower extremity of the incision is at the junction of the middle and upper thirds of the anterior surface of the forearm. The lateral angles are in front of the condyles of the humerus. The area of the skin surrounded by these incisions is excised down to the fascia.

The arm is flexed and the upper extremity of the incision on the arm is sutured to the lower extremity on the forearm. In this manner the arm is flexed and kept in this position without interfering with the bone.

INFECTION OF THE HAND

Infections of the hand and fingers are common. Incisions for infection should be made down to and including the infected tissue, but preferably the periosteum and bone should not be incised unless they have become involved. If infection is superficial to the bone and an incision is made through it to the bone, infection may thus be carried to the bone. The incision is made by blocking the nerves on the proximal side of the infection well out of the region of the inflammation, or it may be done under light general anesthesia, as nitrous oxid anesthesia. The incision should be sufficiently ample to evacuate the inflammatory products, but it is best not to

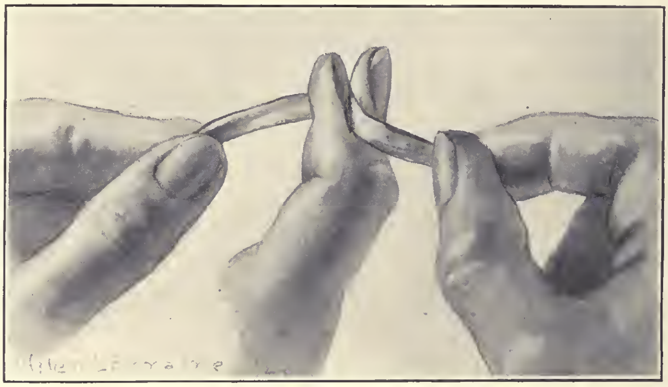

Fig. 362.—Method of Dorrance for incision of felon and placing of drainage.

carry it out of the infected region, for if this is done the natural defenses that have been formed around the infected focus as barriers of lymph and leukocytic infiltration will be broken through by the knife. The bacteria will then have free access to unprotected tissue.

The incision should preferably be made on the side of the finger instead of directly in the palmar surface so as to interfere as little as possible with the action of the tendons. It should be in the long axis of the finger and should not disturb the tactile area.

For infection of the tip of the finger, Dorrance makes an incision parallel to the nail and a short distance toward the palmar side. This separates the nail and its supporting soft tissue from the tip of the finger and the tip of the bony phalanx, practically turning down a palmar flap consisting of the tip of the finger. For drainage a thin piece of rubber tissue is placed across the bottom of the incision to prevent pocketing and to facilitate the discharge of pus (Fig. 362). The resulting scar interferes but little with the function of the tip of the finger.

Inflammation around the nail, or paronychia, begins around the site of the nail. The inflammatory products may be liberated by an incision that goes downward on each side of the root of the nail, turning back the soft tissue as a flap to expose the infection. It is important to remember that the bed of the nail near its root should be disturbed as little as possible, and any incision should be so placed as to avoid this.

In deep infections of the hand and fingers, if recovery is not prompt after the proper application of hot water dressings, an incision should be made. This, however, should not be done until it is evident that either the condition is not improving under the wet dressing, or that there is localization of the inflammatory process.

In deep infection of the hand incisions can only be satisfactorily made under a general anesthetic. The anatomy of the hand, particularly of the bursae, should be borne in mind, and the significance of the fact that the tendon sheaths to the thumb and to the little finger communicate with the bursa of the palm of the hand and wrist should be appreciated. Consequently, infection in the thumb and little finger is potentially more dangerous than infection of the other three fingers. When the index, middle or ring fingers are infected the sheath of the flexor tendons should be incised where the infection appears most pronounced. The length of incision will depend upon the condition. Sometimes two or three incisions of one-half inch in length are more satisfactory than a long incision. When the tendon sheaths of the thumb and little finger are infected the incision should open the bursa in the palm of the hand if the infection has shown the slightest tendency to travel in this direction. Sometimes, however, the inflammatory products will wall off the rest of the bursa and it should not always be taken for granted that if one end of the tendon sheath is infected therefore the whole of the bursa is involved. Infection of the middle palmar space is taken care of by short incisions, preferably in the creases of the palm. If the infection is very deep and appears to involve the back of the hand as well as the palmar aspect, a pair of forceps is carried through a metacarpal space and pushed to the back of the hand. A small rubber tube is drawn through, transfixes the hand, and affords drainage from both the palmar and the dorsal surfaces.

Infection of the thenar space may be reached by a dorsal incision on the radial side of the metacarpal bone of the index finger. Sharp-pointed forceps are passed from this point into the infected area and drainage is inserted. Infection above the annular ligament of the wrist should include not only longitudinal incisions in this region, but incisions in the palm of the hand. These infections are best opened by inserting closed forceps, after incising the skin, and when pus is reached spreading the forceps widely. As shown in the middle of the last century by Hilton, this is much better than cutting into the inflammatory tissue.

It is best not to use too much drainage material for the pressure may cause necrosis and lead to adhesions. If the pus is abundant, however, and rubber tissue is not sufficient, it may be necessary to place a small, soft rubber tube.

DEFORMITIES

A rather common lesion is what is known as Dupuytren's contraction, which is a contraction of the palmar fascia and of those extensions of the palmar fascia that lead to the fingers. The thumb is not often affected. If the skin is adherent it is thrown into wrinkles. The condition has been remedied by different types of operations, depending upon the severity of the disease. Usually only one or two fingers are involved. Occasionally all of the fingers are affected. The ring finger is most commonly involved. Subcutaneous incisions with a tenotome are almost never curative, as the condition rapidly recurs. The most satisfactory operation is complete excision of the diseased portion of the palmar fascia. This is best done by an incision preferably placed so that it will not result in a longitudinal scar in the palm of the hand. Often a triangular flap can be formed by a transverse incision across the palm of the hand which follows the crease of the skin. On the ulnar side another incision is made at a right angle to the transverse incision and triangular flaps of skin are turned back. If this does not afford sufficient room another longitudinal incision can be made on the radial side which will convert the incision into an H with two flaps, one to be turned downward toward the fingers and the other upward toward the wrist. It may be necessary to split the distal flap in order to excise the contracted portion of the palmar fascia which is prolonged on to the finger. The dissection is carefully made, taking care not to wound the tendons. It is essential to close the wound completely, leaving no raw surface. After excising the contracted band the skin itself may retract to such an extent that it is impossible to bring it together without too much tension. Here flaps can be taken from the radial side of the hand or from the back of the hand and turned into the skin defect. In aggravated cases in which a large defect of the skin is left in the palm after dissecting away the contracted tissue, the proper skin covering is best obtained by procedures that have been described in the chapter on Plastic Surgery, such as raising a flap from the abdominal wall, leaving the base attached, and suturing the apex of the flap into the wound. The pedicle is gradually divided. Such a procedure, of course, is only indicated in extreme cases.

The extensor tendon of the finger is occasionally torn in injuries, a condition which is particularly common in baseball players. This renders complete extension of the terminal phalanx impossible and results in what is known as "hammer" finger or "drop" finger. If the finger is seen soon after the injury a splint should be applied, placing the finger in an overextended position until healing has occurred. The splint is left on for a period of two or three weeks. If the condition is not markedly better after this treatment operation is indicated. A transverse incision is made on the dorsal surface along the crease of skin on the distal portion of the affected joint. The ends of the incision curve slightly downward toward the nail so that a flap of skin is turned down which exposes the distal portion of the joint. A short longitudinal incision is made beginning about the center of this trans-

verse incision, at a right angle to it, and going upward in the median dorsal portion of the second phalanx. The two ends of the extensor tendon are dissected and united with sutures of fine tanned catgut. The wound is closed with silk or fine silkworm-gut and a finger splint is used to keep the finger in extension for three weeks.

"Trigger" finger, or "snapping" finger, occurs when flexion or extension has reached a certain point and the finger appears locked. By an extra exertion the obstruction is overcome, a snap occurs, and the flexion or extension is completed. This condition is caused by some obstacle to the action of the tendons which is usually an enlargement of a tendon, or a nar-

Fig. 363.—Line of incision for operation for webbed fingers, palmar surface.

rowing of the tendon sheath. This lesion is found in the fingers and is almost always in the space between the palmar fold at the base of the fingers and the first crease of the skin on the palm. The tendon is exposed by an incision over it and if the trouble is due to a fusiform swelling of the tendon, or to thickening of the sheath, the sheath is split, according to Weir, and left open, and the skin over it is closed. If the obstruction is due to a crumpling up of the flexor tendons by a transverse band of fascia in this region, as suggested by Abbe, the fascia should of course, be divided by a longitudinal incision in the region where most of such trouble occurs, that is, between the palmar creases at the base of the fingers and the next crease in the palm of the hand.

Web fingers may be treated on the general principles of plastic operations. Usually a flap can be obtained from the dorsal surface of one finger with its base on the adjoining finger and a palmar flap made in a reversed direction. If the flaps are not sufficiently long to cover the raw surface of the finger with skin they will at least prevent reunion at the site of the former location of the web and the raw surface on the dorsal or on the palmar aspect of the finger can be covered with skin grafts or permitted to heal by granulations (Figs. 363, 364 and 365).

Fig. 364.—Line of incision for operation for webbed fingers, dorsal surface.

Transplantation of tendons of the forearm is sometimes indicated because of trauma or paralysis. The principles of tendon transplantation in the upper extremity are the same as in the lower extremity, where this operation is more common because of the deformity which follows infantile paralysis.

Occasionally after traumatic paralysis of some nerve, as the musculospinal, or following severe infection or trauma where the tendon may have been destroyed it becomes necessary to transplant a tendon to a different insertion from the normal anatomical insertion or to reconstruct a section of the tendon that may have been destroyed. Certain general principles in

transplantation of tendons have been emphasized by Meyer[1] and should be followed. These embrace the adjustment of a transplanted tendon in such a manner that when the muscle is relaxed and the origin of the muscle and the insertion of the tendon are as near together as possible, the tension on the tendon is zero. Thus it becomes necessary to fix the tendon in its location so that when the limb is in such a position as to approximate the origin of the muscle and the insertion of the tendon as closely as possible there will be no tension on the transplanted tendon. Another principle is that wherever possible the sheath of the paralyzed tendon should be used as a pathway for the transplanted tendon or the tendon should be invested with loose gliding tissue. Wherever possible it should run in the intermuscular

Fig. 365.—The flaps as outlined in the two preceding drawings have been dissected and are being sutured.

plane of fascia. If the tendon perforates this fascia it is sure to acquire adhesions. When such tissue is impossible, as about the wrist joint for instance, a fatty bed is provided. If the neighboring subcutaneous tissue does not afford sufficient fat, a flap with subcuticular fat can be raised from the abdomen, as described in the chapter on Plastic Surgery, and the tendon or tendons to be transplanted are carried through a tunnel of the fat by severing the tendon and then suturing it together. After about two weeks the base of the pedicle of the flap is gradually severed, the tendon together with the skin and subcuticular fat is adjusted on the forearm, and the flap is sutured into its new location. The insertion of the tendon must be buried beneath the periosteum. Function should be begun as early as possible in order to avoid adhesions in the transplanted tendons.

In injuries or infections about the wrist or hand the tendons are often destroyed and it becomes necessary to reconstruct them. Dean Lewis,[2] of

[1]Am. Jour. Surg., 1918, xxxii, No. 1.
[2]Surg., Gynec. & Obst., February, 1917.

Chicago, has done excellent work in reconstruction of tendons of the hand. The tendon of the palmaris longus is often used to bridge defects though it frequently does not afford sufficient material and the transplanted tendon may undergo degeneration and become adherent. With early institution of function, however, satisfactory results are likely to be obtained. Passive or active motion should begin three or four days after the transplantation of tendons.

According to Lewis the transplanted tendon at the end of three weeks is two or three times as large as normal. It becomes fusiform, being largest in the middle and diminishing toward both ends. The enlargement is greatest in the third week and is due to proliferative changes in the peritendineum as well as to swelling in the transplant from insufficient circulation. While there is some degeneration in all transplanted tendons the transplant as a whole is viable and does not act as a bridge to convey tenoblasts from one end of the resected tendon but new tissue is formed from the transplant itself. If, however, the tendon is transplanted experimentally where it cannot function the proliferative changes do not occur, but the tendon atrophies without any attempt at proliferation. Function greatly stimulates the proliferative changes.

Fig. 366.—Method of applying the tendon suture of Frisch.

A strip of fascia lata may serve as a tendon and, in the opinion of Lewis, is preferable to tendon for repair of defects in the tendons of the hand. Where the injury is extensive and the scar tissue dense it is best first to transplant a flap of skin from the abdomen containing much subcutaneous fat. This should be abundant enough to make a bulging or "humping" in the region in which it is transplanted, for if enough fat is not provided it is difficult for the tendon to function on account of adhesions. Some of the excessive fat will be absorbed and if objectionable, some may be removed later. After the skin and fat flap from the abdomen has become acclimated and its nutrition established in its new location, reconstruction of the tendons is begun. If this is done with strips of fascia lata, as Lewis prefers, the subcutaneous fat is tunnelled with an artery forceps so that the transplant of fascia lata will run entirely through a fatty tunnel. When the muscles are thrown into action the sutures should hold the ends of the transplant well approximated to the tendon that is its host. Tendons cannot be sutured by simple interrupted sutures as they will cut out. The tendon suture of Frisch[3] is very satisfactory (Fig. 366). The play of the flexor tendons of the forearm is greater than the play of the extensors, so interference by adhesions is more marked with the flexor tendons. In the flexor tendon a tube of fascia

[3]Surg., Gynec. & Obst., February, 1917, p. 132.

lata is used instead of a strip which will suffice for an extensor tendon. When the skin on the flexor side of the fingers has been destroyed and is replaced by scar tissue, new skin is first transplanted along with subcutaneous fat after removing the scar. When this has become well established the fascial tube used to reconstruct the defect in the flexor tendon is carried

Fig. 367.—Transplantation of tendon of the flexor carpi radialis for paralysis of the extensor muscles of the forearm according to J. B. Murphy. The tendon is divided and a tunnel is formed under the skin.

through small incisions and a tunnel is made in the fat of the transplanted skin. The fascial tube should surround the end of the tendon on the proximal side and can be firmly attached by the Frisch suture to the tendon. The fascial tube is made with the fat side internal. The end of the reconstructed tendon, after being carried through the subcutaneous fat, is sutured to the periosteum in the region of the normal insertion of the tendon. In order

to simulate the bands that prevent the tendon from strutting with flexion a ring may be worn over the finger.

McArthur suggests implanting the fascial strip in the fat before it is removed. The strip of fascia to be transplanted is dissected up but left attached at both ends, subcutaneous fat is placed about it and the wound closed. Six weeks later the wound is reopened and the strip of fascia along

Fig. 368.—A skin incision is made four inches higher and the tendon is drawn through.

with its surrounding attached fat is transferred to the forearm and hand and sutured in position. This seems to be an excellent procedure.

John B. Murphy transplanted tendons from the flexor surface of the forearm to the extensor tendons in order to overcome paralysis of the musculospiral nerve. This was accomplished in the following manner: The tendon of the flexor carpi radialis is divided just below the annular ligament through

a short longitudinal incision. Blunt dissection with long scissors is carried up about four inches beneath the skin as far as the muscle of the tendon. This is done by inserting the scissors closed and spreading the blades, then withdrawing and inserting the closed scissors again (Fig. 367). Another incision is made at the upper point of this blunt dissection about four inches above the annular ligament and the tendon of the flexor carpi radialis is

Fig. 369.—A third incision is made on the back of the wrist and the tendon of the flexor carpi radialis is pulled through.

drawn through this incision (Fig. 368). This gives the tendon the proper angle for its maximum amount of contraction. A short vertical incision is then made on the back of the wrist over the extensor tendons of the fingers and closed forceps are pushed through from this incision to the upper incision on the forearm, grasping the end of the tendon of the flexor carpi radialis and pulling it through the tunnel made by the forceps to the incision

on the back of the wrist. This tunnel is made in the subcuticular fat (Fig. 369). The tendon passes through the split tendons of the extensor longus and extensor brevis pollicis, the two extensor tendons of the index finger, and the extensor tendon of each of the other fingers. This insertion is made in such a way that the tendons of the thumb and index finger receive the greatest amount of pull, though when full extension is made all five fingers are extended (Fig. 370). The thumb and index finger, however, can be slightly extended without extending the other three fingers.

Obstruction of the lymphatics of the arm produces marked swelling. This occurs not infrequently after cancer of the breast and if it appears several weeks or months after a radical operation for cancer it is probably due to the blocking of the lymphatic channels with cancer cells. Operations

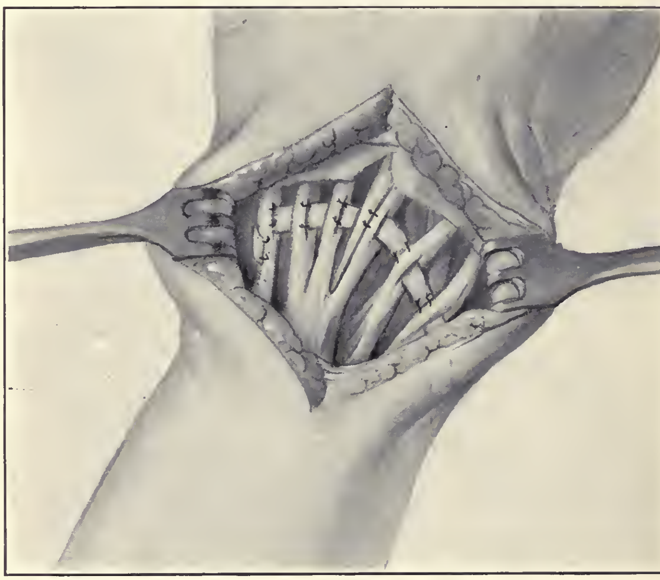

Fig. 370.—The tendon is inserted into the extensor tendons of all five fingers in such a manner that the pull will be first exerted on the thumb and index finger.

for edema of the arm and forearm following cancer give but temporary relief, but occasionally even this is justifiable. In the rare instances in which the blockage is not due to malignant disease, operation may be indicated.

According to the method of Handley, an incision about one inch long is made through the skin in the front of the forearm immediately above the wrist. A long probe with an eye at the proximal end is introduced through this incision and is pushed upward and outward beneath the skin to a point near the elbow. It is cut down upon and exposed. The probe is threaded with a long line of doubled stout silk and this is drawn through from the lower incision to the upper incision. The thread is clamped at the level of the lower incision so that only one-half of it can be drawn through. The probe is reintroduced in the incision at the elbow and pushed under the

skin to a point on the arm over the insertion of the deltoid and the silk is carried with it and is unthreaded. The probe is again introduced at the original incision above the wrist, threaded with the other end of the silk and is pushed inward and upward and made to appear through a short incision in the skin on the inner side of the elbow. The probe carries the other end of the thread (Fig. 371). From this point it carries the thread through to the upper incision over the insertion of the deltoid and from there both probes are introduced under the skin and carry both threads to the back of the arm to an incision made in the posterior border of the deltoid. By a similar procedure silk is buried under the skin on the back

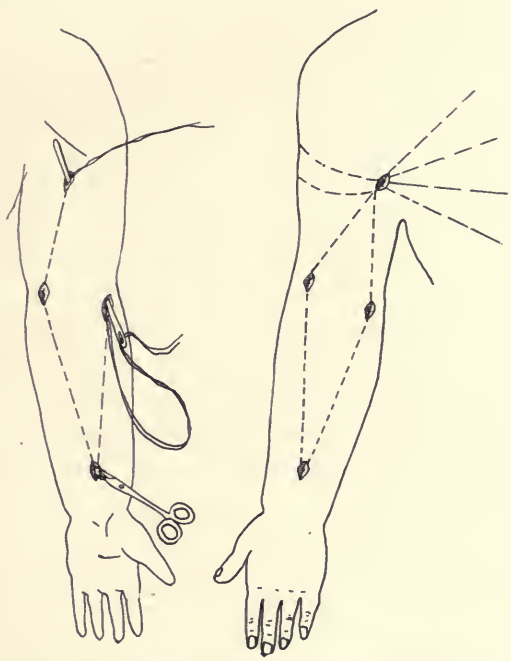

Fig. 371.—Placing of silk threads on anterior surface of arm and forearm to relieve swelling of the upper extremity. (Handley.)
Fig. 372.—Placing of silk threads on the posterior surface of the arm and forearm.

of the forearm and the silk made to appear through the incision in the skin at the posterior border of the deltoid. The ends of the four threads are now cut so they will be shorter than the probe and one of the four ends that emerge through the upper posterior incision is threaded into a probe and the probe is thrust full length, eye first, through the upper posterior incision under the skin of the back over the region of the scapula, and so the probe is unthreaded and leaves the silk in the tunnel made by the probe. The probe is then withdrawn and the procedure is repeated till all four of the silk threads have been placed in different directions. In this way the threads are carried in a radiating manner under the skin of the back (Fig. 372). The incisions are closed with sutures. This operation of Handley is

devised to create new lymphatic channels along the threads and so to increase the flow of lymph along the newly created lymph channels as to relieve the edema.

The operation of Kondoleon depends upon a different principle. While the operation of Handley seems to create new lymphatic channels that of Kondoleon promotes anastomosis between the superficial and deep lymphatics. If both sets are blocked the operation of Handley is indicated but if the swelling

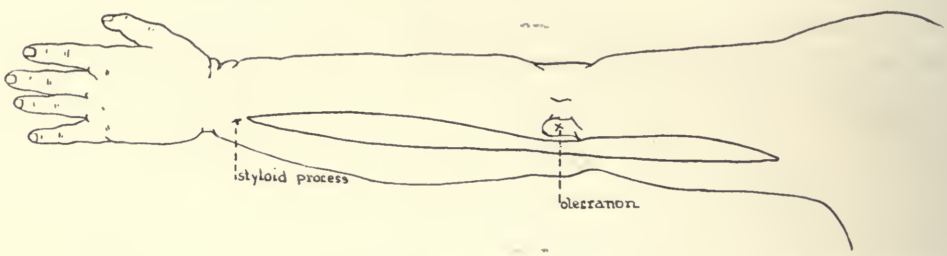

Fig. 373.—Lines of incision for operation of Kondoleon along the outer border of the upper extremity.

is due to obstruction in the superficial lymphatics, when the deep set is free from obstruction, the operation of Kondoleon is best.

Sistrunk,[4] of the Mayo Clinic, has obtained very satisfactory results from the Kondoleon operation. A long narrow elliptical incision is made on the outer aspect of the limb extending from the wrist to a few inches below the shoulder joint (Figs. 373 and 374). The skin incision is so made that the wound can be readily closed. The skin is retracted and under each edge of the retracted skin a long cut is made through the edematous fat

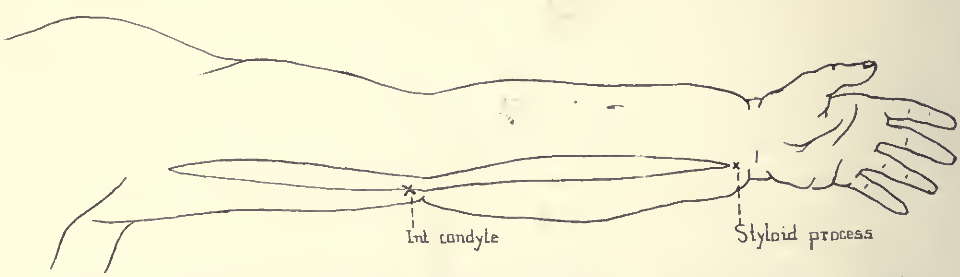

Fig. 374.—Lines of incision for operation of Kondoleon along inner border of the upper extremity.

down to and through the deep fascia. A piece of tissue including the skin, much of the undermined fat, and a strip of fascia, is removed. The vessels are carefully clamped. The edges of the fascia may be turned under and sutured to the muscle, though if a sufficient strip of fascia has been removed this is not necessary. The skin is approximated in the usual manner without drainage. If this is not satisfactory a similar incision can be made on the inner side of the arm a few weeks later.

[4]Jour. Am. Med. Assn., 1918, lxxi, p. 800.

SUBACROMIAL BURSITIS

Codman, of Boston, has described an inflammation of the subacromial bursa, which is often responsible for trouble with the shoulder joint. This affection is frequently accompanied by deposits of lime salts in the tendon of the supraspinous muscle and Brickner thinks that tears or bruises of this tendon are often followed by the deposit of lime salts on its surface. When these deposits are present with subacromial bursitis it is necessary to remove them. Codman advises operation by making an incision from a point midway between the coracoid and the acromion processes downward about two and one-half inches, splitting the fibers of the deltoid muscle. The bursa should be cut down upon carefully as in entering the peritoneum and its surface is recognized and incised. As much of the adherent or thickened bursa is removed as possible and the wound is closed in layers. Motion should be begun in about ten days. Brickner opens the bursa from an incision which goes downward from the outer border of the acromion over the greater tuberosity of the humerus toward the external condyle. The fibers of the deltoid muscle are split and retracted. The bursa is carefully opened and adherent bands are divided. By rotating the arm the whole subacromial bursa is explored. The floor of the bursa is then incised in the same line as the skin incision over the greater tuberosity of the humerus and the insertion of the supraspinatus tendon is exposed. The bursa is dissected from the tendon and any deposits of lime salts are removed. If the tendon shows evidence of an injury this region is trimmed away and the tendon is sutured. If the roentgenogram has shown deposits of lime salts in the tendon these should be removed by splitting the tendon down to the deposits, and after removing the lime salts the tendon is sutured with catgut. The wound in the floor of the bursa is closed with fine catgut stitches and the roof of the bursa is similarly closed. The deltoid and the skin are sutured separately and the arm is placed in the position of abduction until healing takes place.

Codman operates to restore the supraspinatus tendon if it has been injured by being pulled from its insertion into the head of the humerus, by making an incision as in his operation for subacromial bursitis and then continuing the upper end of the incision over the root of the acromion process directly back over the shoulder. The acromio-clavicular joint is divided. The base of the acromion is severed with a wire saw, care being taken to avoid injury to the suprascapular nerve. A small portion of the trapezius muscle is divided and the acromion process along the deltoid and the outer half of the wound is retracted outward. If the supraspinatus muscle has been torn the articular portion of the joint is visible, but if the operation is merely exploratory, this muscle must be divided before the joint can be seen. The tendons are sutured with tanned catgut and the acromion process is united by tanned catgut or tendon sutures passed through drill holes on either side of the saw line.

CHAPTER XIX

OPERATIONS ON THE LOWER EXTREMITY

AMPUTATIONS

The same general principles that have been emphasized in amputations of the upper extremity also apply to amputations of the lower extremity. The problems are slightly different, however, because of the necessity of weight bearing on the stump of the leg, for which there is no occasion after amputation of the arm. The World War has thrown much light upon the problem of amputation, particularly concerning the most efficient stump.

Starr[1] speaks of the desirability of having an ideal stump in leg amputations. He defines such a stump as one that is best suited for an artificial appliance for that portion of the leg. The ideal stump should have a linear scar, be free from puckering or infolding of the skin, and with sufficient flap but no redundancy. There should be a pad of fat and subcutaneous tissue over the head of the bone, but it should not be adherent. The joint next above the amputation must have a full range of motion. Such a stump is not often obtained, but it should be kept in mind and an effort made to secure it whenever amputation is necessary.

The guillotine operation is even more unsatisfactory in the lower extremity than in the upper extremity and should but seldom if ever be done. It probably provides but little if any more against infection than the other types of amputations and it makes a secondary operation, as a rule, imperative. The better methods of dealing with infection have caused the guillotine operation to be discarded.

Stumps may harbor infection either in the soft tissues or in the bone, and in military surgery there is very apt to be a foreign body which will cause an ulcer or a sinus. A stump which shows a persistent ulcer or sinus should be operated upon under a tourniquet, the sinus or ulcer excised well into healthy tissue, and diseased bone or foreign body removed if present. This is much better than blindly scraping with a curet in a bloody field.

Spurs of bone are sometimes the cause of pain and may be due to the snapping off of the last portion of the bone before sawing has been completed, or to the lack of proper removal of the periosteum and endosteum.

Painful neuromas are best avoided by following the suggestion of Huber and Lewis, which has already been mentioned, and injecting the nerve trunk with alcohol just above the point of section. The nerve should be well pulled down so that after section it will retract into the soft tissues. Starr finds that amputation of the toes with a plantar flap causes almost no disability. One toe should never be left, for it becomes deformed and is of no use. The tarso-

[1]Jour. Am. Med. Assn., Nov. 22 1919, pp. 1585-1590.

metatarsal amputation is satisfactory, according to Starr, if the peroneus muscles are left intact on the outside and the tibial on the inside. The midtarsal amputation, however, results in an unbalanced foot with elevation of the heel and gives a stump that cannot be properly fitted either with an artificial foot or boot. This method of amputation, which is known as the classical Chopart, should never be done. In its stead the Syme operation gives excellent results when properly performed.

Amputation of the leg should not be done within four inches of the ankle joint, because a stump too near the ankle will make it impossible satisfactorily to fit an artificial leg. Above this point, however, the longer the stump the more helpful will be the application of an artificial appliance, because there is greater leverage and, consequently, better walking and less limping.

According to Starr the term "site of election," as applied to leg amputations should be dropped, for it is a source of confusion. Below the knee the stump may be so short as to be useless. In the thigh the lower the stump the better the leverage. The Gritti-Stokes amputation is one of the best thigh amputations when an artificial limb is to be used. In elderly people with gangrene of the foot or leg the Stephen Smith operation through the knee is exceedingly good and easily performed. The chief fault of the Gritti-Stokes operation is that the approximation of the patella to the end of the femur is often unsatisfactory and unequal. A stump shorter than five inches from the perineum can rarely be fitted with an artificial leg without a pelvic band. After amputation at the trochanter minor or above this point, including amputation at the hip joint, it is necessary to have a "pelvic cradle" or "tilting table", as it is called by the English manufacturers, which has an automatic lock both at the hip and the knee.

Aside from the Syme amputation at the lower end of the tibia and the Gritti at the lower end of the thigh, a complete end bearing stump is rarely possible, according to Starr, though by a hammock suspended in a bucket the stumps may take much of the weight.

Amputation through the knee joint is difficult to fit with an artificial appliance, as the joint must necessarily be much lower than the normal knee joint; but if good covering is provided for the condyles, preferably with an anterior flap, it will make a fairly good end bearing stump. Because of the liability of infection in military surgery some operators prefer this type of amputation to the Gritti-Stokes, thinking that in the latter operation it is difficult to obtain satisfactory results in the presence of infection.

Amputation of the toes may be done in the same general way as amputation of the fingers (Fig. 375). The insertion of the tendons and their general arrangement in the foot are similar to the insertion in the hand. As much tissue as possible should be saved if it can be sufficiently nourished. The great toe is exceedingly important and is far more valuable than any other toe. The distal end of the first metatarsal bone should also be preserved wherever possible, as it constitutes the anterior pedestal of the plantar arch. It is

essential that in all amputations of the toe the scar should fall on the dorsum of the foot and not on the plantar surface. As the toes are short, disarticulation is usually done and there is not often occasion to amputate through the bone. The length of the flap is one and one-half times the diameter of the toe and it should be a plantar flap. If a full plantar flap cannot be obtained the racket or oval method may be used. Amputation or disarticulation of the great toe at the metatarsophalangeal joint is best done by a type of racket incision that begins over the middle of the joint on the dorsum of the foot and is carried along the junction of the upper and inner sides of the great toe to the distal end of the first phalanx. From this point the incision curves around the inner surface of the toe, then the under surface, and finally along the outer surface of the toe to the web and to the point of beginning of the incision. It must be remembered that in speaking of inner or outer portion of the toe in an anatomical sense the outer portion is that nearest

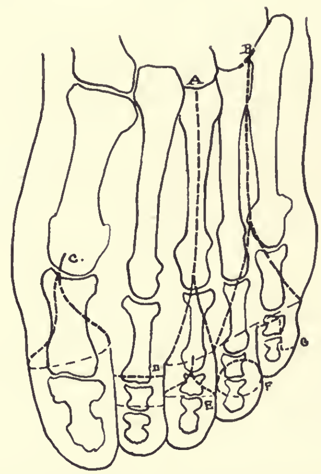

Fig. 375.—Lines of incision for amputation of the toe: *A*, disarticulation of the middle toe with its metatarsal bone; *B*, disarticulation of the two outer toes with their metatarsal bones; *C*, amputation of the first toe; *D*, *E*, *F*, and *G*, the lines of different types of incision for amputation of the toes.

the little toe. The flexor and extensor tendons are divided about the middle of the first phalanx so that these tendons can be sewed together across the end of the stump. The joint is opened on the dorsum and the capsular ligament is divided close to the phalanx in order to leave as much as possible to cover the end of the bone. The flexor tendons may be sutured to the extensors. If this cannot be done the sheath of the flexors should be closed with sutures. If this type of operation is not desirable on account of the injured tissue, a long plantar flap serves an excellent purpose. Any one of the other toes can be disarticulated or amputated at the metatarsophalangeal joint and if a long plantar flap cannot be secured the racket incision with the straight incision on the dorsum of the toe and extending down over the metatarsal bone gives good results. If possible the flexor and extensor tendons should be cut long so they can be sewed over the stump.

If it is necessary to amputate four toes the remaining one should also be amputated.

In disease of a metatarsal bone the metatarsal bone and the corresponding toe can be removed by a long dorsal incision over the metatarsal bone which ends in an oval incision surrounding the toe and forming a sufficiently long plantar flap to prevent the scar from lying on the bottom of the foot. The incision begins on the dorsum of the bone to be removed about opposite the metatarsotarsal joint. It must be remembered that the metatarsal bone of the second toe fits back slightly farther in the tarsus than do the

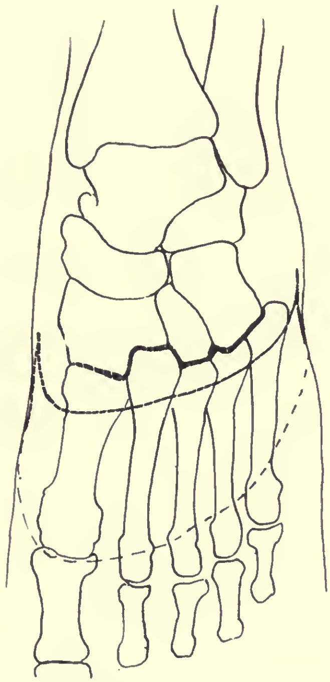

Fig. 376.—Lines of incision for amputation at the tarsometatarsal joint (Lisfranc's amputation).

other metatarsal bones. The extensor tendon is divided through the upper portion of the incision. In the great toe or the little toe, however, the tendons are divided if possible at a point sufficiently below the site of amputation to permit the flexor and extensor tendons to be sewed together, or at least to be attached to the periosteum. In the other toes the tendons are of no great importance when the metatarsal bone is to be removed. If the bone is to be divided and not disarticulated a wire saw should be used, being careful to protect the soft tissues. Amputation or disarticulation of two or more toes with their metatarsal bones can be done with a racket incision that is merely an extension of the same type of incision used for amputation or disarticulation of a single toe. It must always be borne in mind to secure as much of the plantar flap as possible. It may be necessary to afford exposure of the base of the metatarsal bones

by an additional T-shaped or L-shaped extension at the end of the long racket incision. If the outer metatarsal or the inner metatarsal bones are to be removed along with the toes the incision should be so shaped as to have a long plantar and a short dorsal flap.

Amputation at the tarsometatarsal joint, or Lisfranc's amputation, gives very satisfactory results (Fig. 376). The incision begins with the foot in plantar flexion at a point just posterior to the base of the metatarsal bone of the little toe and is carried in a slightly curved direction forward along the outer side of the foot about one inch. Then the incision curves across the dorsum of the foot one-half an inch below the line of the tarsometatarsal joint and is carried backward to the inner side of the foot a short distance behind the base of the metatarsal bone of the great toe. Care should be taken to protect the insertions of the peroneus muscles and of the tibialis anticus on the outer and inner sides of the foot. The extensor tendons are divided and the incision is carried down to the joint. As this is done the foot is bent forward so as to expose the joint. The dorsal flap contains as much of the subcutaneous tissue as possible and is dissected up just above the tarsometatarsal joint. The plantar flap begins at the point of beginning of the dorsal flap, that is just posterior to the base of the fifth metatarsal bone, and is carried forward and slightly inward. It curves across the sole about opposite the heads of the metatarsal bones and is carried to the point of termination of the dorsal flap on the inner side of the foot. The plantar flap should be somewhat longer on the inner side than on the outer, because there is more bony surface to cover in this region. The incision for the flap is carried down to the bone, taking care to protect the plantar arteries. The flap is dissected back to a point just above the tarsometatarsal joint and includes all the flexor tendons and other soft parts down to the bone. The joint is disarticulated by first dividing the dorsal ligaments with a strong, narrow bladed knife, beginning at a point between the first metatarsal bone and the internal cuneiform. The knife is then firmly inserted between the first and second metatarsal bones, carried backward to the base of the second metatarsal bone, and a similar cut is made between the second and third metatarsal bones. Then the joint between the second metatarsal and the middle cuneiform is severed by a transverse incision. The rest of the metatarsal bones are separated from the tarsus by opening the joint from above downward. If there is any difficulty about disarticulating the second metatarsal bone on account of its deep insertion its base may be sawed across. This will give a very satisfactory stump. It is much better to do this than to adopt the suggestion of Hey and saw off a part of the internal cuneiform bone, as this may affect the insertion of the tibialis anticus to such an extent as to jeopardize the usefulness of the foot. The arteries are tied. They include the dorsal interosseous, the communicating branches of the dorsalis pedis, the four digital arteries in the plantar flap, the two terminal communicating branches of the dorsalis pedis, the internal plantar and some times the external plantar. The flexor and extensor tendons are sewed to-

gether over the bone in order to give better control of the stump, and then the plantar and dorsal flaps are approximated. If there is too great a tendency for the heel to be pulled up, the tendo Achillis should be cut.

The operation of Chopart, or disarticulation of the foot through the midtarsus, has been practically discarded as the insertion of the anterior tendons are cut away, and there is nothing to oppose action of the tendo Achillis. This operation makes an unbalanced foot and it should not be done. The Pirogoff amputation, in which the posterior portion of the os calcis is fixed to the lower end of the tibia, and the malleoli have been sawed off, has not given satisfactory results and is difficult of execution. The modification in which the os calcis is sawed transversely instead of vertically, as in the Pirogoff operation, seems theoretically better, but practically the results are no better. The Syme operation seems to be the most useful of any operation in the region of the ankle joint. If amputation cannot be done at the tarso-

Fig. 377.—Lines of incision for amputation of Syme at the ankle.

metatarsal joint, the Lisfranc operation, the next site would be just above the ankle according to the method of Syme.

In Syme's amputation an incision is made to the bone from the tip of the external malleolus down across the sole of the foot to a point about one-half inch below the internal malleolus. The center of the incision is curved very slightly toward the heel. The upper ends of this incision are joined by a straight incision carried across the front of the ankle joint. (Fig. 377.) The foot is bent strongly downward and the ankle joint is freely opened from the front, dividing also the lateral ligaments. Great care should be taken in dissecting the soft parts on the inner side of the ankle to avoid injury to the posterior tibial artery and its branches, as this is the most important supply of nutrition to the flaps. As the joint is further opened the tendo Achillis and the heel flap are dissected from the os calcis from above downward, keeping as close to the bone as possible. The flaps

are retracted and both malleoli together with a very thin slice of the tibia are removed with a saw. The posterior or heel flap is brought forward and sutured so that it will bear all the pressure on the stump.

If the Syme amputation cannot be done the next point of amputation should be on the leg about four inches above the ankle joint, because of the difficulty of fitting an artificial leg or foot at a point closer to the ankle joint. This may be done by flaps or by the oval method. A long posterior and a short anterior flap make an excellent stump. If the long posterior flap is taken it should be more from the posterointernal aspect than from a strictly posterior surface. The incision begins on the inner side of the tibia and is carried down below the sawline for a distance about equal to one and one-fourth diameters of the limb. It then goes back across the leg and upward to a point opposite its beginning. The anteroexternal flap is formed by an incision which goes forward and slightly downward halfway around the leg and is so placed as to make the short flap about one-third to one-half the length of the long flap. The incisions are carried through the skin and fascia and are then deepened to the bone. The flaps are retracted above the level of the saw line and the bone is divided. The crest of the tibia, which is sharp, is beveled so as to prevent pressure. The periosteum and endosteum are removed and the nerves treated as has been described in amputations of the arm. In amputations of the lower extremity the stump must bear great strain and weight. Removal of the periosteum and endosteum, as has been described in the general remarks on amputation of the upper extremity, together with the treatment of the nerves in the stump is, for these reasons, particularly appropriate here. The tendo Achillis and the muscular structure in its neighborhood are brought forward and sutured across the bone to the tendons and muscles of the anterior portion of the leg. The long flap is so sutured to the short flap that the scar will not lie over the end of the bone, but will be anterior. This is usually called Farabeuf's operation.

In the middle third of the leg a long posterior and a short anterior flap amputation is excellent (Fig. 378). This is called Hey's operation. The circular or oblique method or equilateral flaps may be used. In amputation through the middle or the upper third of the leg the fibula should be cut about one-half inch shorter than the tibia. Through the upper third of the leg some operators prefer to disarticulate the fibula entirely. In making the incision for amputation through the middle third of the leg by a long posterior and a short anterior flap the posterior flap should be broad and U-shaped, its breadth being equal to one-half the circumference of the limb at the saw line and its length equal to one-third of this circumference. The incision begins one inch below the saw line, is carried down the leg just behind the inner border of the tibia, and curves backward broadly on the back of the leg. The outer incision passes downward just behind the fibula and back of the peroneus muscles and curves onto the back of the leg, uniting with the inner incision. The anterior flap is one-third the length of the pos-

terior flap and is formed by joining the vertical incisions to form the posterior flap about the junction of their middle and upper thirds by an incision across the front of the leg, which curves slightly downward. These incisions are made while the knee is flexed. The incision is carried down through the skin and fascia and the posterior muscles are cut while the flaps are retracted. The vertical incisions are deepened and the anterior muscles are divided. The muscles are detached from the bone and the interosseous membrane above and the interosseous membrane is divided. The periosteum is removed either before or after the bone is sawed. The endosteum is removed. The crest of the tibia is beveled. The nerves are treated as usual and the muscles are carefully sutured over the ends of the bones as there is a tendency for the posterior muscles to pull backward. The skin flap is sutured in the usual way.

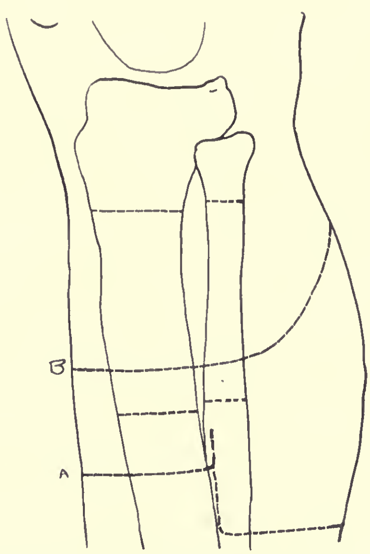

Fig. 378.—Lines of incision for amputation of leg: *A*, Hey; *B*, Stephen Smith.

Amputation through the upper third of the leg may be made by a large external flap according to the method of Farabeuf, or by a bilateral hooded flap according to the method of Stephen Smith. In the operation of Farabeuf a U-shaped flap, whose length is equal to the diameter of the leg at the saw line is outlined by beginning the incision about opposite the saw line in front, carrying it down just internal to the crest of the tibia and curving across the outer portion of the leg (Fig. 379). The incision then passes vertically upward opposite the anterior incision but terminates about one and one-half inches below the saw line. The transverse incision is carried across the inner aspect of the leg, curves slightly downward, and unites the upper end of the posterior incision with a point on the anterior incision about one and one-half inches below its beginning. The external flap is dissected up along the lines of the retracted skin and fascia, carrying the incision to the bone.

The anterior incision is deepened to the anterior border of the tibia and the tibialis anticus is freed from the bone. The entire muscle mass is separated from the tibia, the interosseous membrane, and the fibula by knife and elevator. It is important not to injure the anterior tibial artery after it has been severed at the end of the flap. If the flap is dissected too high behind where the vertical incision is short the anterior tibial artery may be cut before it penetrates the interosseous membrane. The transverse incision is carried down on the line of the retracted skin and fascia and the interosseous membrane is divided. The periosteum is divided and dissected down about one-half inch above the saw line and the bones are divided after retracting

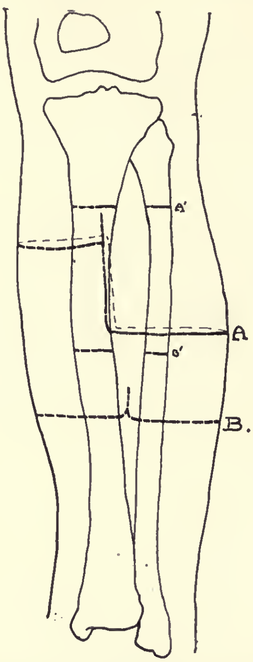

Fig. 379.—Lines of incision for amputation of leg: *A*, Farabeuf; *B*, amputation by modified circular method.

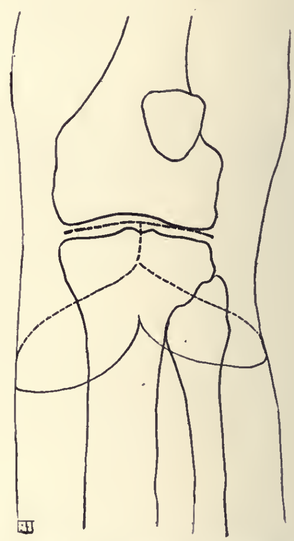

Fig. 380.—Lines of incision for amputation of Stephen Smith at the knee joint.

the soft parts. The crest of the tibia is beveled and the endosteum at the end of the sawed bone is removed. The fibula is sawed about one-half inch higher than the tibia. The nerve trunks and vessels are treated in the usual way and the muscle flaps are sutured together over the ends of the bones. The edges of the external flap are sutured to the transverse internal incision.

Amputation through the middle or upper portion of the leg should be followed by the application of a posterior splint in order to prevent flexion of the stump.

Amputation through the upper third of the leg may also be done by the bilateral hooded method of Stephen Smith (Fig. 378). As has already been stated, however, the amputation should not be made too near the joint as too

short a stump makes it impossible to fit an artificial leg satisfactorily. The surgeon grasps the leg so as to mark the upper limit of the anterior incision with his left thumb about three-fourths of the diameter of the leg below the saw line on the anterior border of the tibia and the upper extremity of the posterior incision by his left index finger about opposite the saw line of the bone. He begins by incising the posterior tissue at the tip of the index finger, then cuts downward and curves the incision gradually to the side of the leg, carrying it curving slightly upward to the end marked by his thumb. A similar incision is repeated on the other side of the leg, except that the flap is made a little larger on the inner side than on the outer. The flaps of skin and fascia are dissected up for about an inch and are retracted and the muscles are divided in a circular manner to the bone. The interosseous membrane is divided and the bone is sawed across as in the operation of Farabeuf. The muscles are sutured across the stump of the bone and the skin is closed in the usual manner.

Amputation or disarticulation at the knee may be done by the bilateral hooded method of Stephen Smith (Fig. 380), though an elliptical or oblique circular incision, or a long anterior flap may be employed. The operation of Stephen Smith at the knee joint is similar to that of Stephen Smith in the upper third of the leg. The original technic calls for a covering of only skin and fascia, but this can sometimes be advantageously modified by first dissecting the lower ends of the flap for about an inch and then dividing the muscles and soft parts by a circular incision and retracting these structures to the joint. The incision begins behind, in the midline, at a point about opposite the line of the knee joint in the midpopliteal space and is carried downward vertically for about two inches, then gradually downward and forward over the outer part of the leg, and finally upward, ending at a point about one inch below the tibial tubercle. The internal flap is similar, but is slightly larger to cover the larger internal femoral condyle. The tissues are dissected for about an inch and the muscles and soft tissues are divided to the bone and retracted to the level of the joint. As much of the capsule of the joint is included as possible. The semilunar cartilages are kept with the ligaments of the joint so as to afford greater protection to the condyles. The joint is entered between the head of the tibia and the semilunar cartilage. The knee is then flexed and the crucial ligaments are divided. The knee is extended and the other ligaments holding the knee are severed. The vessels and nerves are treated in the usual way and the flaps so sutured that the scar is posterior and in the intercondyloid notch.

This operation is an excellent one for amputation through the knee, particularly in the old when the amputation is done for gangrene of the foot. It makes a broad stump which bears well, but it is objectionable because the broadness of the stump makes it difficult to fit an artificial leg and because the joint of the artificial leg has to be at a lower level than the normal joint.

In amputating through the thigh as much stump as possible should be saved on account of the leverage. Most of the weight of an artificial limb is borne not on the end of the stump but on other portions of the stump and on

the tuberosity of the isehium. A firm, painless stump, however, is most desirable. As a rule, a long anterior and short posterior flap amputation is preferable. The retraetion is greater on the posterior and inner part of the thigh than elsewhere, so allowanee must be made for this, and it should also be borne in mind that the lower the amputation the greater the retraetion. The eireular method of amputation in the thigh, however, often gives very satisfaetory results, though the advantage of the long anterior flap is that it drops over the end of the bone and does not permit the tissue to sag back as with equal flaps or a long posterior flap.

Above the knee the most satisfaetory amputation elose to the knee is not the transeondyloid, but the supraeondyloid operation, or the Gritti-Stokes, in whieh a long anterior and a short posterior flap are employed. The transeondyloid operation is unsatisfactory from the standpoint of fitting an artifieial leg. In the supraeondyloid amputation, or the Gritti-Stokes, the operation is so planned that the division of the femur is made about three-fourths to one ineh above the adduetor tuberele, so the patella ean be applied to a transverse seetion of bone about its size (Fig. 381).

The ineision for a long anterior flap in this operation begins one ineh above the prominenee of the internal eondyle and is carried downward and slightly forward making a broad eurve and erossing the upper part of the leg just below the tuberele of the tibia. It eurves upward and outward to a point one ineh above the external eondyle. The incision for the posterior flap, whieh is shorter than the anterior flap, begins at the upper portion of the ineision for the anterior flap, eurves baekward and downward, ending at the eorresponding point on the opposite side of the leg. It is so fashioned that the posterior flap is about one-third the length of the anterior flap. These flaps are disseeted upward and the skin and faseia of the anterior flap are freed until the ligamentum patellæ is reaehed, which is divided and with the patella turned up with the anterior flap. The posterior flap is disseeted up and eonsists solely of the skin and faseia. Both flaps are retraeted to the saw line, whieh is about three-fourths to one ineh above the adductor tuberele and all tissues are divided to the bone by a eireular ineision. The periosteum here is not removed as in the usual amputation. The bone is sawed. After the vessels and nerves have been treated in the usual way the patella is seized with a heavy foreeps and its artieular surfaee is sawed away or removed with bone foreeps The denuded surfaee of the patella is applied to the stump of the femur. It may be held in position by splinters or pegs of bone taken from the end of the femur and driven through holes that have been drilled through the patella into the end of the femur, or it may be fastened by two stout kangaroo tendon sutures passed through drill holes in the patella and in the end of the femur. If there is too mueh forward pull of the tendon of the quadrieeps the tendon may be partially divided. The periosteum and the tissues about the femur are fastened to similar tissue over the patella and the anterior and posterior flaps are sutured together in the usual manner.

Amputation through the lower third of the thigh may be done by a long

anterior and a short posterior flap, or by the circular or oblique circular method, or by equal flaps, for sometimes on account of the character of the injury one of these methods may be necessary to secure satisfactory flaps (Fig. 382). Probably the best method for amputation of the thigh anywhere, except in immediate proximity to the joint, is by a long anterior and a short posterior flap. The length of the anterior flap is equal to one and one-half times the diameter of the thigh at the saw line and its breadth is slightly greater. The incision begins opposite the saw line, about the middle of the inner surface of the thigh, and passes down the inner portion of the thigh, curving forward

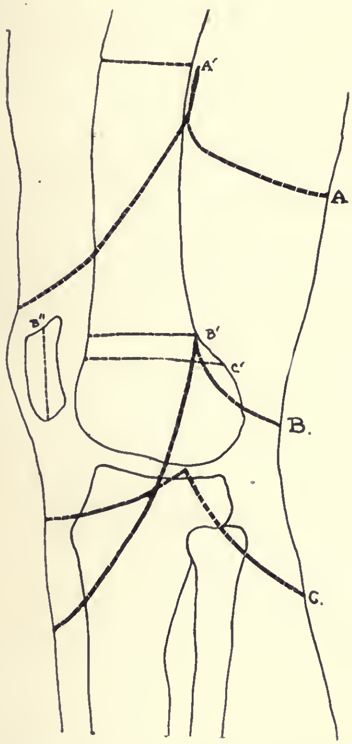

Fig. 381.—Lines of incision for amputation of the thigh: *A*, by long anterior and short posterior flaps; *B*, by the method of Gritti-Stokes; *C*, by Lister's modification of Carden's operation.

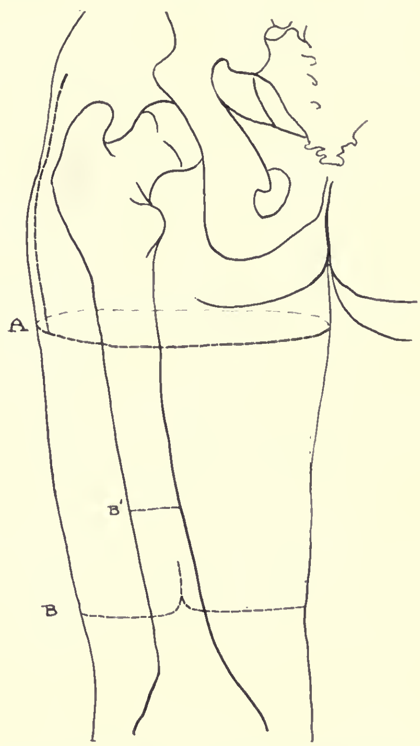

Fig. 382.—*A*, lines of incision for amputation of the hip joint by the method of Wyeth. (The external racket incision.) *B*, lines of incision for amputation of the thigh by modified circular method.

broadly over the anterior surface to a distance below the saw line equal to about one and one-half times the diameter of the thigh at the saw line. (Fig. 381.) It then broadly curves upward on the outer portion of the thigh to a point about opposite its beginning. The incision for the posterior flap begins at the upper end of the incision for the anterior flap and is carried over the posterior portion of the leg, curving so that the posterior flap is only about one-third as long as the anterior flap. Because of the great amount of retraction it is well to make generous allowance for flaps in amputation of the thigh. After the skin and fascia of the anterior flap have retracted the muscles under this

flap are divided obliquely from without inward, forming a flap of the muscles of the anterior portion of the leg. The dissection is carried through the muscle down to the level of the saw line in an oblique manner. The thigh is raised and the posterior flap is dissected and a short flap of muscle is made by cutting the muscle obliquely from the surface down to the bone as in the anterior flap. In this way the anterior and the posterior flaps consist of beveled tissue with the sharp edge downward and the base about the level of the saw line of the bone. The muscles are fully divided down to the bone and are retracted. The periosteum is removed from the bone for about half an inch above the saw line and the bone is sawed. The endosteum is removed and the irregularities on the end of the bone are treated in the usual manner, particular care being taken to smooth the bone along the line of the linea aspera.

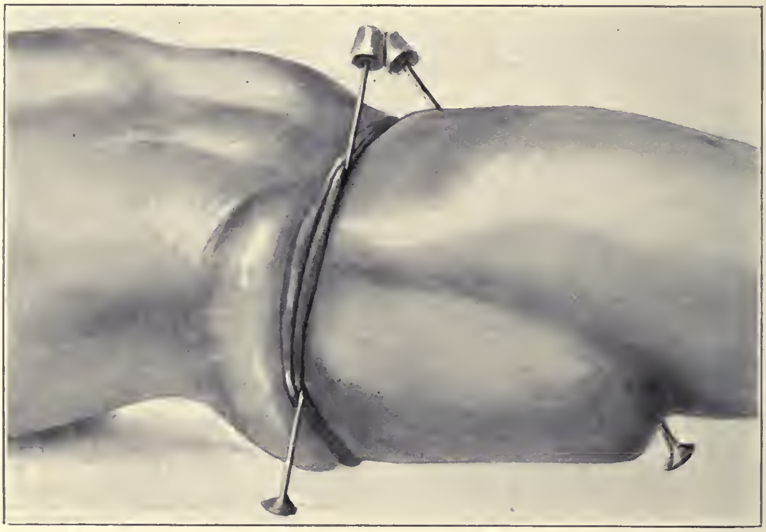

Fig. 383.—The method of Wyeth for hemostasis in amputation at the hip joint.

The nerves and vessels are treated in the usual manner and the muscles in the anterior flap are sutured to the muscles in the posterior flap with heavy mattress sutures of catgut. The fascia is also approximated and the skin flaps are closed in the usual manner.

Amputation just below the trochanters may be done by the external oval method, or by the racket incision, which is used in amputation at the hip joint. The incision begins over the great trochanter in the outer portion of the thigh, is carried down the outer portion of the thigh for about four inches, then anteriorly along the front, and then across the inner aspect of the thigh in an oval manner. The posterior incision begins about four inches below the point of beginning of the vertical incision and passes downward and backward, meeting the anterior incision on the back of the thigh at a point about six inches below the level of the trochanter major. The skin and fascia are dissected up for about two inches along the lines of the incision and the shaft

of the bone is exposed through the vertical incision. The muscles are then divided by a circular cut on a line with the retracted flap. The soft tissues are retracted and the femur is sawed just below the trochanter. The muscles are sutured together with mattress sutures of catgut and the skin flap is sutured in a horizontal line from within outward.

The great problem of amputation at the hip joint has been the control of hemorrhage. In individuals who are thin and where there is much disease about the hip joint this can be done by an anterior racket incision, which first exposes the femoral vessels so they may be controlled and divided in the early stage of the operation. With careful dissection the bleeding points may be clamped as they are reached and but little blood is lost. When, however, there is no pathology at the level of the hip joint which may be adversely affected by the tourniquet, or when the patient is large and muscular the bleeding should be controlled by the application of a rubber tourniquet according to the method of Wyeth (Fig. 383). In this method pins or mattress needles about two-sixteenths to three-sixteenths of an inch in diameter and ten inches long are inserted through the thigh. One pin, entering the outer portion of the thigh just below and to the inner side of the anterior superior iliac spine, passes through the superficial muscles and fascia on the outer side of the hip and emerges about three inches from, and on the same level with, its point of entrance. The second pin is introduced on the inner portion of the thigh about one-half inch below the perineum and internal to the saphenous opening. It traverses the adductor muscles and emerges about one inch below the tuberosity of the ischium. Sterile corks are placed on the sharp ends of the pins or mattress needles to prevent injury to the hand of the operator. A small compress of gauze is placed over the femoral artery and rubber tubing about one-third of an inch in diameter is wrapped tightly four or five times around the thigh just above the needles and is fastened by tying the ends with a bandage and by clamping them with pedicle forceps. A circular incision is made around the thigh about six inches below the anterior part of the tourniquet and then a vertical incision begins above the great trochanter just below the tourniquet and passes downward, joining the circular incision. The circular incision goes only through the skin and fascia, which are dissected to the level of the lesser trochanter about two inches (Fig. 382-A). Here the muscles are divided to the bone by a circular incision and the vertical incision which has previously been made is deepened to the bone. The large vessels are then clamped and tied. Through the vertical incision which is carried to the bone the tissues are separated from the shaft and tuberosity of the femur and the soft parts are retracted. The muscular attachments to the trochanter are divided with scissors while the limb is rotated alternately inward and outward. The capsular ligament is divided at its outer front border and the cotyloid ligament is incised to let in the air and overcome the suction of the joint. The posterior portion of the capsule is divided. The head of the femur is then twisted out of position by rotating the thigh. If this proves in any way difficult, which is unusual, the margin of the acetabulum may be

chipped away with a chisel to let in the air, or if the vessels have been caught and tied the tourniquet may be removed and the disarticulation completed. After tying all the vessels that can be found the tourniquet is loosened to see if any vessels have been overlooked. The muscles are approximated by mattress sutures of stout catgut. Drainage by a rubber tube carried to the acetabulum is established, the tube being removed in forty-eight hours. The skin wound is sutured from within outward, making a continuous line. An abundant dressing is applied with firm compression.

If, because of the pathology about the hip joint, or the thinness of the patient, it is advisable not to use a tourniquet, the anterior racket method is satisfactory. The method of Wyeth is an external racket incision. The anterior racket incision begins about the center of Poupart's ligament and passes

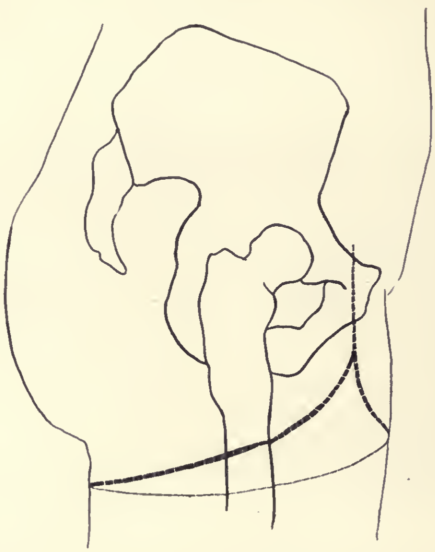

Fig. 384.—Lines of incision for amputation at the hip joint by the anterior racket incision.

down over the femoral artery for three inches, then curves inward and crosses the inner portion of the thigh about four inches below the perineum (Fig. 384). From this point it is carried across the posterior and outer aspect of the thigh a short distance below the great trochanter, and then curves upward and inward to join the lower end of the vertical incision two inches below Poupart's ligament. Through the vertical portion of the incision the femoral artery and vein are exposed, carefully ligated, and divided. Two ligatures at distances of about one-fourth to one-half an inch are placed upon the femoral artery, as has been insisted upon in the general description of amputations. This is particularly important here because of the large size of the vessel and the great pressure within its lumen. The skin and fascia are freely dissected along the entire incision and the muscles on the outer side of the thigh are divided, the external circumflex artery being doubly clamped and tied. The thigh is

elevated and the dissection is carried backward, dividing the insertion of the gluteus maximus muscle. The thigh is then rotated and the muscles on the posterior and inner portion of the thigh are divided. Carefully clamping the bleeding points and searching if possible for the internal circumflex artery, the muscles in the internal portion of the thigh are divided on a level with the retracted skin. The thigh is adducted and rotated inward and the muscles attached to the great trochanter are severed. The femur is then adducted and rotated outward and the capsule cut and any tendons that have not been divided are severed. The capsule is divided with a long knife or with curved scissors. The muscles and skin are sutured together as after the amputation by Wyeth's method, except, of course, the line of sutures runs from before backward instead of from within outward, as with Wyeth's method. By a careful technic this incision by the anterior racket method in suitable cases can be carried through with but little loss of blood.

TENDONS AND MUSCLES

The three types of operations on tendons are lengthening a tendon, shortening a tendon, and transplanting of tendon and muscle from its normal insertion to another position to take the place of a paralyzed or weakened muscle and to produce a proper balance between the flexors and extensors of a joint.

Tenotomy may be open or subcutaneous. The regeneration of a tendon is practically perfect, particularly of such a tendon as the tendo Achillis. This regeneration is facilitated by the presence of a part of the tendon sheath, so it is important not to divide completely the whole of the tendon sheath in doing a tenotomy, for if it is cut entirely across, this portion of the repaired tendon may become adherent and composed largely of scar tissue that does not blend readily with the normal tendon. Subcutaneous tenotomy should not be done where there are important blood vessels or nerves that might be accidentally injured.

If the open operation for tenotomy is done the skin and subcutaneous fat over the tendon are incised, the sheath of the tendon is opened and the tendon split in its middle for a half inch, separating its fibers vertically. At one extremity of the incision half of the tendon is cut across at a right angle to the slit and at the other extremity of the slit the other half on the opposite side is divided. In this manner the tendon resembles a step and the ends may be sutured together or left free. The open operation is sometimes done by cutting the tendon diagonally from side to side. If it is sutured, fine tanned or chromic catgut or silk is used. The incision in the skin is made somewhat to one side of the prominent line of the tendon so that the scar in the skin will not fall on the most prominent position. The tendon should be handled carefully and should not be clamped unless it is intended to cut away the portion that is clamped.

In subcutaneous tenotomy, such as tenotomy of the tendo Achillis, the tendon is divided by the insertion of a small sharp-pointed tenatome through

the skin beside and beneath the tendon. This is done from the inner side of the leg when the tendo Achillis is divided, which is the usual structure on which this operation is done. After puncturing the skin it is safer to use a dull pointed tenatome passed beneath the tendon. The blade is then turned so that the cutting edge faces the tendon and the foot is strongly flexed dorsally. This makes the tendon very tense. It is divided by a sawing motion, care being taken not to cut the skin. When the fibers are completely divided it gives way with a popping sound and the heel is immediately lowered.

There need be no fear that the tendo Achillis will fail to unite after a properly done tenotomy, for in large clinics where thousands of these operations are performed lack of union is almost never seen and is then probably

Fig. 385.—Open tenotomy by the zigzag or step method.

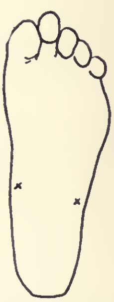

Fig. 386.—Points of entrance of the tenotome in subcutaneous tenotomy of the plantar fascia. (Soutter.)

due to the fact that the sheath of the tendon has been completely divided. By keeping close to the tendon and using a blunt-pointed tenatome after the initial puncture there is but little danger of total division of the sheath.

Open tenotomy is sometimes used for relief of contraction of the flexor longus digitorum. Here an incision about two inches long is made half an inch back of the internal malleolus through the skin and fat. The tendons of the flexor longus digitorum are exposed and pulled upon to assure the surgeon that they are connected with the toes. The tendons may be lengthened by the step method, or zig-zag tenotomy as it is sometimes called, or by an oblique incision (Fig. 385). They are then sutured with fine chromic or tanned catgut. The sheath and the subcutaneous tissues are brought to-

gether with catgut and the skin is closed. Usually skin closures over a tenotomy or transplantation are more satisfactory when done with silkworm-gut than with catgut, as this causes less reaction in the skin.

In club foot operations subcutaneous tenotomy of the plantar fascia is often performed. The tenotome has a narrow blade and is sharp-pointed. The surgeon holds the ball of the foot in his left hand and inserts the tenotome perpendicularly through the skin at the inner edge of the tense plantar fascia and between the skin and the fascia which is demonstrated by flexing the foot dorsally and bringing out the strong contracting bands. The fascia is divided in various directions until the contracting bands are all severed. Care is exercised not to cut the skin for the wound may be torn in subsequent manipulations. The deep tendons are also avoided. If all the bands cannot be reached by division from the inner edge of the plantar fascia the tenotome can be inserted at the outer edge (Fig. 386).

Contraction of the tendons of the tibialis posticus and the peroneus muscles is best treated by open tenotomy. The tendon of the tibialis anticus may be divided subcutaneously at the inner side of the foot. It may be brought into prominence by adducting and pronating the foot.

Tendons are shortened in different ways. If the tendon extends into the muscle it may be shortened over the belly of the muscle by a step or zig-zag incision, as described in open tenotomy, cutting the ends of the tendon to make it shorter and then suturing the two halves together laterally. It must be recalled that any suturing of tendons should be of the mattress type or else the suture should be quilted in because the ordinary interrupted suture placed in end-to-end union of the tendon will split its fibers and will not hold. If it is desirable to secure a particularly strong union and if the extra bulk is not objectionable, the ends of the tendon may be overlapped without cutting away any of it and sutured to each other laterally. The amount to be excised is judged by lifting the tendon and taking a fold, if it is small, until an idea can be had of the amount necessary to be removed.

The principles of transplantation of tendons have been discussed in describing tendon operations in the upper extremity. The same principles apply in the lower extremity, except that the tendons and tissues are more powerful and extra care should be taken to secure the sutures. The transplanted tendon should be sutured with medium size braided silk in which there is no antiseptic to irritate the tissues. This silk is sterilized solely by heating. It is tested with the hands before being used in order to be sure that there are no weak spots. If it is clamped at its ends the knot must be so tied that the clamped portion is not included in the portion of the silk that is left in the tissues. The knot is tied three times and the ends should be just long enough to be tucked singly in the tissues without being erect. The method of tendon suture called the Frisch suture described on p. 362 is excellent when uniting tendons to each other by the end-to-end method. If a tendon is to be trans-

planted into a bone or periosteum the braided silk is quilted into it for a distance of about two inches above the end. The suture is started at the end of the tendon and is threaded in a straight needle, usually a round needle, unless there is considerable scar tissue in the tendon. It is passed back and forth at a right angle to the fibers and at short intervals for about five insertions and it is then returned in a similar manner. If the tendon is to be transplanted into the periosteum, one end of the braided silk is threaded into a curved needle and quilted through the periosteum three times. The other end of the silk is similarly quilted through the periosteum and the end is tied. Sometimes a notch or a groove is cut in the bone and the end of the tendon is buried into the groove and sutured to the periosteum or ligaments in the neighborhood. If the bone can be drilled through and the drill opening enlarged with a burr the tendon can sometimes be carried through the hole in the bone and fastened to the periosteum on the opposite side. This is the technic employed in the operation of Sir Robert Jones of transplantation of the extensor proprius hallucis to the head of the first metatarsal bone. An excellent method of securing the end of a transplanted tendon is to insert it through a slit in the paralyzed tendon near the insertion of the latter. After pulling the transplanted tendon through this slit it is fastened with sutures at the point where it transfixes the paralyzed tendon. A second slit is then made in a somewhat different direction lower down and the end of the transplanted tendon is also brought through this second slit and fastened. In this manner the transplanted tendon is brought through a slit made in the paralyzed tendon anteroposteriorly, through another slit made laterally farther down, and is then fastened securely with sutures.

Where it is possible to do so it is well to transplant the tendon sheath along with the tendon, as it adds additional protection and promotes the nutrition of the tendon. If, however, its course is in the subcuticular fat, the fat will soon form a sheath. It is important that the tunnel be abundantly large, for there is a tendency to contraction which will bind and cause adhesions to the transplanted tendon if the tunnel is not of sufficient size.

Paralyzed muscle usually has a greyish or greyish pink color, but healthy muscle is a deep red. It is highly important that the healthy and paralyzed muscles be thoroughly differentiated before any operation is undertaken. This may be done by electrical reaction and sometimes it is necessary to have the services of a neurologist in order to be certain that the motion that exists is not due to the compensating action of some adjoining muscle or group of muscles. The so-called trick motions, especially after paralysis due to nerve injuries, may be very deceptive.

In all tendon transplantations it is best to have a tourniquet so the operations may be done in a bloodless manner. The Esmarch bandage is first applied from the toes to where the tourniquet is to be placed so as to make the field entirely bloodless.

In all transplantations the deformity for which the operation is done should be thoroughly overcorrected before the tendon is transplanted, else

the tension will be so great that the transplant will not be placed in a favorable condition for healing.

When the tibialis anticus muscle is paralyzed, which is common after infantile paralysis, the tendon of the peroneus muscle may be transplanted to give dorsal motion to the foot. The incision, according to the Lange method, begins one inch above and half an inch posterior to the tip of the external

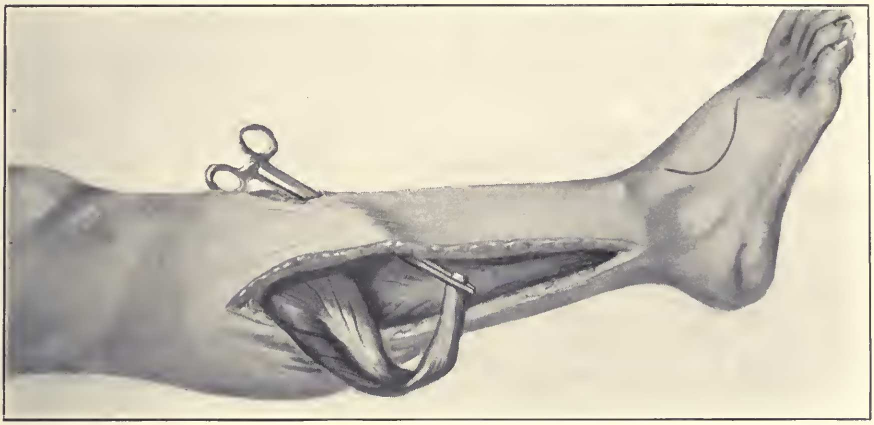

Fig. 387.—Transplantation of the tendon of the peroneus muscle. The tendon and muscle have been freed and are about to be drawn through an anterior incision.

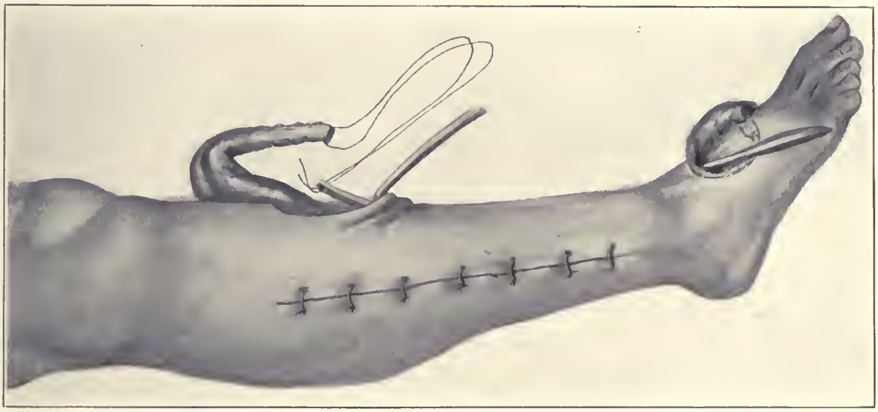

Fig. 388.—A suture is inserted in the tendon according to the method of Frisch, a tunnel is made from the dorsum of the foot to the upper anterior incision, and the tendon is about to be drawn through the tunnel. (Lange method after Soutter.)

malleolus and goes upward to the middle of the leg parallel to the fibula. The strong fibrous sheath about the malleolus is not opened or divided as this will weaken the joint unnecessarily. If the peroneus muscles appear to be vigorous and of deep red color the lower end of the incision is pulled downward by a retractor to permit access to the tendon below the lowest point of the incision. Both the long and short peroneus muscles may be transplanted at the same time, though transplantation of the long peroneus is the only one that

is necessary. The peroneus tendon is cut as low down as possible after pulling it up, retracting the wound down, and catching it with a hemostat as low down in the wound as possible (Fig. 387). This clamped portion of the tendon at the tip should always be cut away in any transplantation, as union is made much better if this bruised portion is cleanly cut away. The muscles are dissected from the bone with a sharp scalpel until a line of cleavage is reached and then dissection may be continued bluntly. Care must be taken to avoid injuring the branch from the external popliteal nerve, which lies near the bone anterior to the peroneus muscle. Another incision is made about two inches in length over the anterior middle portion of the leg down to the fibers of the tibialis anticus muscle. A tunnel is made in the subcutaneous fat connecting the two incisions at the upper portion of the long incision and the tendon of the peroneus muscle is passed through this tunnel. The tunnel should be abundantly wide (Fig. 388). Stout braided silk is quilted into the tendon, as

Fig. 389.—The tendon of the peroneus has been transplanted and sutured into the tissue over the dorsum of the foot. (Soutter.)

has already been described, after cutting off its clamped end. The tips of the silk ligature are clamped and a tunnel is made in the subcutaneous fat down to the front of the midtarsus region (Fig. 389). The point of insertion into the tarsus depends upon the deformity. If the tibialis anticus is the chief or only muscle that is paralyzed the insertion should be about the middle of the tarsus, but if the tibialis anticus has some power the insertion may be a little further to the outer side. A curved incision is made over the tarsus and a flap is formed with its base internal which will overlie the point at which the tendon is to be transplanted. The base of the flap should be abundantly broad so as not to interfere with its circulation. The tendon is then carried through the tunnel from the second incision to the tarsus by a pedicle forceps, a tendon carrier, or a long uterine dressing forceps. Whatever instrument is used is inserted from below upward and an abundantly large tunnel is made in the subcutaneous fat. The silk is then quilted into the periosteum and ligaments of the tarsus, as has been described in the general remarks on tendon trans-

plantation, by threading each end of the silk into a curved needle, passing it at least three times in the periosteum and ligaments and tying the ends three times. The tension should, of course, be properly regulated so that it is certain that the tendon or muscle has free play in the tunnel and will slide easily and that the tendon when the silk is tied holds the foot in about the desired position without marked tension. After tying the silk the other tendons of the foot that have been retracted are permitted to cover the insertion of the silk, the deeper tissues are closed with fine tanned or chromic catgut, and the skin is sutured with silkworm-gut. The leg and foot are held in such a position as will relax the transplanted tendon and should be kept strictly in this position for about ten days, when the patient may be permitted on a bed rest, but the foot is kept quiet for six weeks. After about two months the patient can walk on crutches and a small amount of weight bearing with plaster of Paris holding the foot in position is permitted.

Usually in this transplantation it is wise to weaken the opposing muscle by a subcutaneous tenotomy of the tendo Achillis.

The tibialis posticus can also be transplanted to take up the action of the paralyzed tibialis anticus. Here an incision is made parallel to the tibia beginning about one inch above and one-half inch posterior to the internal malleolus and extending to the middle of the leg. The tendon of the tibialis posticus is isolated and distinguished from the flexors of the toe by pulling on the tendon and noting the action on the toes. The tendon of the tibialis posticus is clamped with a hemostat as far down as possible, divided, and the tendon and muscle are dissected to the middle of the leg. The end of the tendon is quilted with braided silk, an incision is made over the front of the tibia about its middle, and a subcutaneous tunnel is formed connecting the two incisions. The tendon and muscle of the tibialis posticus are passed through this tunnel and the tendon is inserted in the tarsus as described in the operation of transplanting the peroneus. The flexor longus digitorum, the extensor longus hallucis, or the extensor longus digitorum may also be transplanted for a weak or paralyzed tibialis anticus.

When the peroneus muscles are paralyzed half of the tendo Achillis may be transplanted forward. The incision begins half way between the outer malleolus and the outer edge of the tendo Achillis and is carried up the middle of the leg exposing the outer portion of the tendo Achillis with its muscle and the peroneus muscle and tendon. The outer half of the tendo Achillis is divided at the os calcis, split up, and carried forward where it is attached to the peroneus tendons through a slit in these tendons. This half of the Achilles tendon is quilted with a silk suture which is then quilted into the peroneus tendon; or it may be held in position by chromic or tanned catgut sutures which fasten it securely to the peroneus tendon after the proper amount of tension has been estimated.

In total paralysis of the tibialis posticus half of the tendo Achillis may be brought forward into the tendon of the tibialis posticus in the inner side of the leg as described in transplantation of half of it in the peroneus.

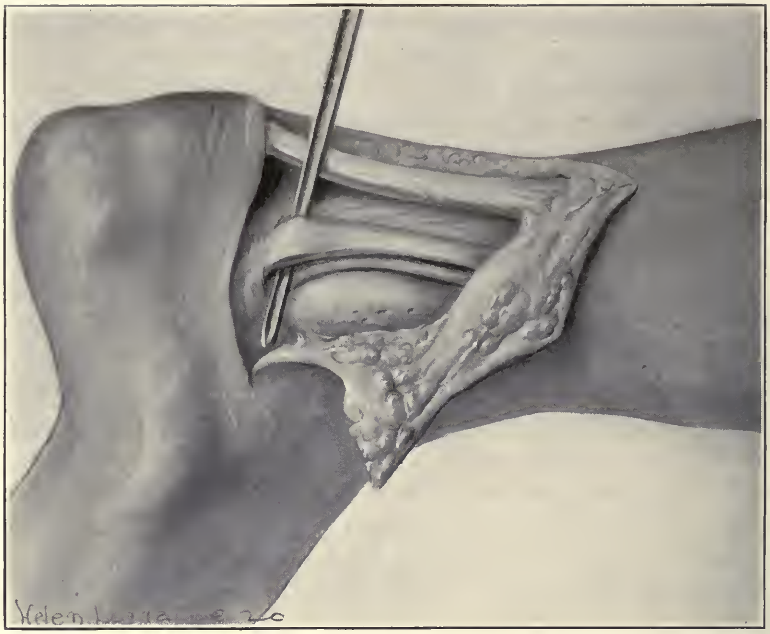

Fig. 390.—Transplantation of the tendon of the peroneus longus into the tendo Achillis. (Sir Robert Jones.)

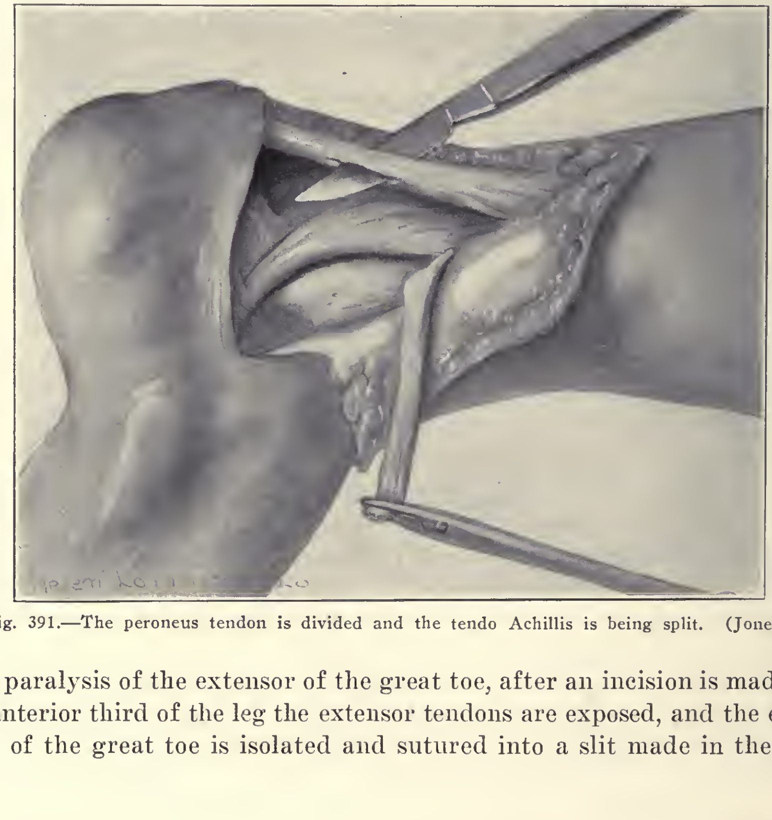

Fig. 391.—The peroneus tendon is divided and the tendo Achillis is being split. (Jones.)

In paralysis of the extensor of the great toe, after an incision is made in the lower anterior third of the leg the extensor tendons are exposed, and the extensor tendon of the great toe is isolated and sutured into a slit made in the tendon

of the tibialis anticus. Care should be taken not to make the tension too great as "hammer" toe might result.

In paralysis of the calf muscles, which results in talipes calcaneus, transplantation of the peroneus longus tendon into the tendo Achillis has given excellent results in the hands of Sir Robert Jones. Here, as elsewhere, the deformity should be overcorrected as far as possible before transplantation of the tendon. The patient is placed so that the tendo Achillis is uppermost and an incision is made slightly to its outer side and extending upward from its insertion four inches. After exposing the tendon thoroughly a second incision is made beginning about half an inch above the lower end

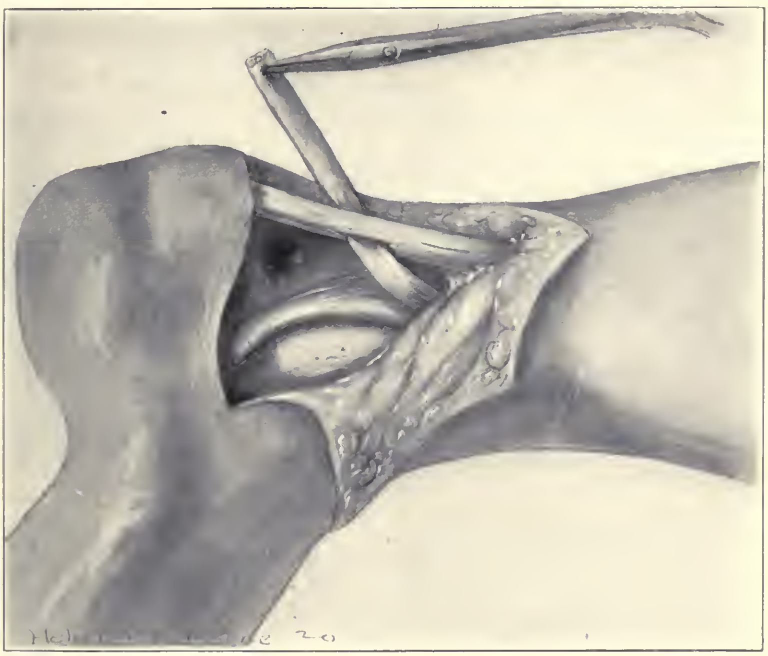

Fig. 392.—The peroneus tendon is drawn through the slit in the tendo Achillis. (Jones.)

of the first incision and passing beneath the external malleolus for about two and one-half inches along the outer portion of the foot. The triangular flap thus made is dissected up and the peroneus longus tendon is exposed just below the external malleolus (Fig. 390). The peroneus brevis tendon lies just external to the tendo Achillis and behind the tendon of the peroneus longus (Fig. 391). The peroneus longus tendon is isolated and divided as close to its insertion as the incision permits. The tendo Achillis is split laterally with a knife about one and one-half inches above its insertion. A long pair of forceps is passed through this slit in the tendo Achillis, going from within outward, and the end of the tendon of the peroneus longus is grasped in the forceps and pulled through this slit (Fig. 392). According to the method of Jones the peroneus longus is now anchored in this slit with two sutures of chromic

catgut, which transfix the tendo Achillis and the tendon of the peroneus longus as it passes through the slit. A second slit is made in the tendo Achillis lower down and just above its insertion. A pair of forceps is passed through this slit from without inward and the end of the peroneus longus tendon is grasped and drawn through this lower slit in a reversed direction from that in which it was drawn through the upper slit (Fig. 393). The tip of the tendon which has been grasped with forceps is cut away and the tendon is fastened in position with sutures of tanned or chromic catgut. The peroneus longus will then pull upon the tendo Achillis and so will correct the talipes calcaneus. The skin is closed with silkworm-gut and the leg is put up in gauze with a padded posterior flexible splint, which is curved well down over the sole so as to hold the foot in a marked equinus position to take the strain from the transplanted tendon.

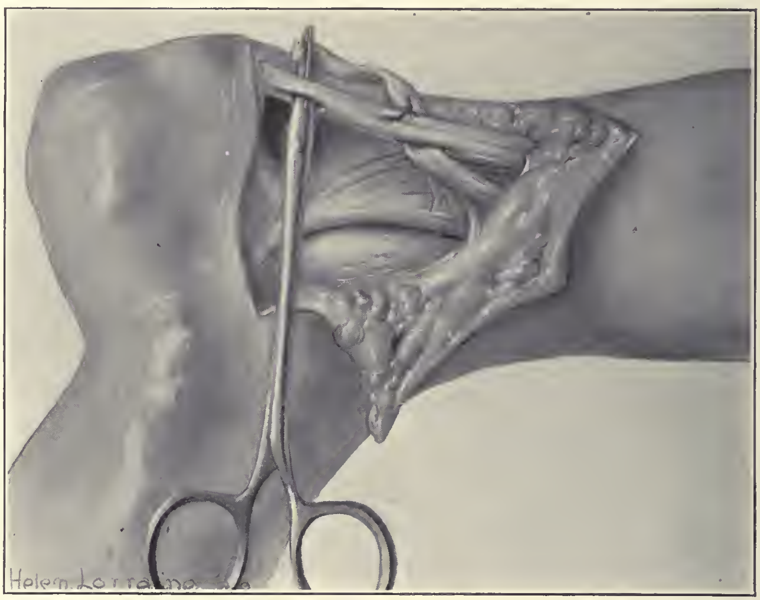

Fig. 393.—The peroneus tendon is drawn through the second slit in the tendo Achillis. (Jones.)

The extensor proprius hallucis may be transplanted to the head of the first metatarsal bone to overcome a moderate degree of claw foot due to a paralysis of the short flexors of the foot. Before this operation is done the deformity should be overcome by stretching and by subcutaneous tenotomy of the plantar fascia, and also by excision of an oval portion of the skin from the dorsum of the foot in front of the ankle (Fig. 394). After these preliminary procedures have been done a two-inch incision is made over the tendon of the extensor proprius hallucis, beginning at the level of the web between the great and the second toe and going upward (Fig. 395). The tendon with its sheath is isolated and mobilized by blunt dissection as thoroughly as possible, a hemostat is applied as close to its insertion as can

Fig. 394.—Excision of a diamond-shaped area of skin on the dorsum of the foot. (Sir Robert Jones.)

Fig. 395.—Exposure of tendon of the extensor proprius hallucis.

be done after extending the toe and the tendon is divided. About one and one-half inches of the tendon is now freed from the surrounding tissue and an incision beneath it is carried down to the periosteum, which is divided and turned

back, exposing the bone just behind the head of the first metatarsal bone. A small hole is drilled through the first metatarsal just behind its head and this hole is enlarged with a burr until it is such a size that the tendon can be carried through the opening (Fig. 396). A half-inch incision is made through the plantar surface of the foot opposite the under surface of the head of the first metatarsal bone and is carried down to the bone. The end of the tendon is transfixed with catgut in the straight needle and the catgut is brought through the hole in the metatarsal bone by the needle, which is passed downward and emerges through the plantar incision (Fig. 397). The catgut draws the tendon through the hole in the metatarsal bone and the tendon is fastened in this position by passing one end of the catgut through a part of the plantar fascia

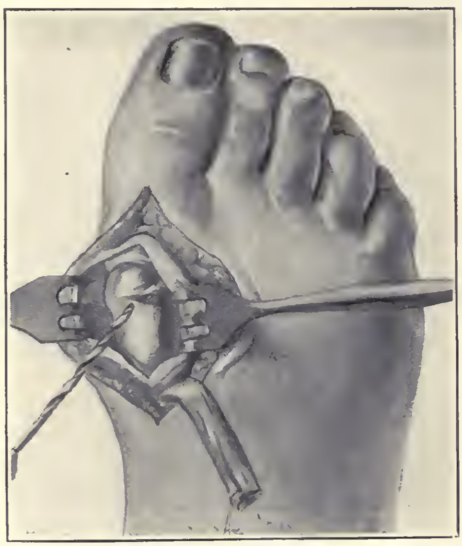

Fig. 396.—Drilling a hole in the head of the metatarsal bone for transplantation of tendon of the extensor proprius hallucis. (Sir Robert Jones.)

and tying the ends of the catgut. In this manner the end of the tendon is attached to the plantar fascia and is prevented from slipping back through the hole in the metatarsal bone. The incision in the plantar surface of the foot is closed with a suture of silkworm-gut. In the wound on the dorsum of the foot the tendon and periosteum of the dorsum of the metatarsal bone are united by a suture of catgut to give additional fixation and the skin is closed with interrupted silkworm-gut. A padded splint is placed along the back of the leg and the sole of the foot to keep the foot at a right angle. This takes the strain from the transplanted tendon while it is healing and so gives it physiologic rest. The stitches are removed in ten days and massage is instituted in about three weeks. The splint is removed entirely in six weeks and the patient may then begin to walk.

For paralysis of muscles about the knee joint transplantation of the hamstring muscles, inner or outer, or of the sartorius, is usually done. The indica-

tions are paralysis or paresis of the quadriceps femoris. If all of the muscle is totally paralyzed it would probably be better to transplant both the inner and outer hamstring muscles, or at least the biceps and the semitendinosus and gracilis. The muscle to be selected also depends upon the extent of the paralysis or paresis. The muscle to be transplanted should be a deep red or at least a pinkish red. A grey muscle, which of course is paralyzed, will be of no service if transplanted. If the outer hamstring muscle,

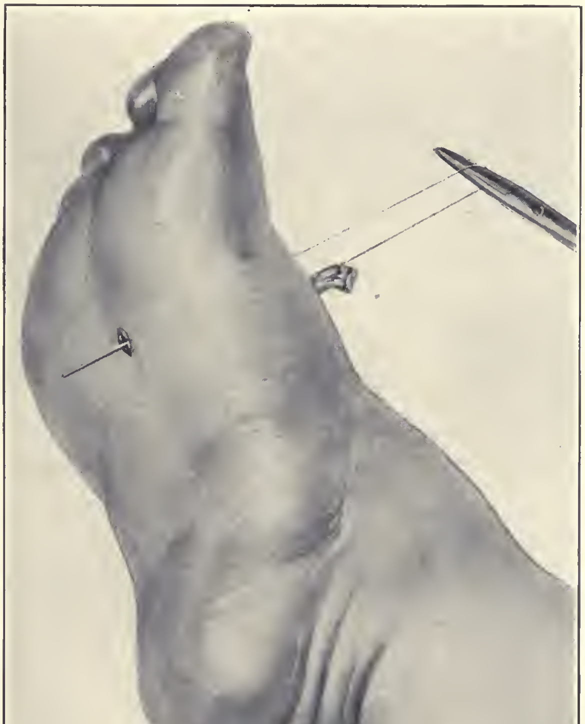

Fig. 397.—The method of drawing a tendon through a drill hole in the head of the metatarsal bone. (Sir Robert Jones.)

the biceps, is used it should be inserted into the inner border of the patella to stabilize the joint, likewise the inner hamstring muscles should be placed in the outer portion of the patella. The muscles should always be dissected up one-half their length.

According to Sir Robert Jones, transplantation of the biceps tendon is done by first making an incision about five inches in length over the biceps, the lower portion of the incision reaching not quite to the insertion of the tendon. The external popliteal nerve lies just internal to the biceps tendon and must be carefully avoided. After the tendon is dissected down nearly to its insertion by retracting the lower angle of the incision, it is grasped

with a pair of forceps and thoroughly freed with knife dissection. It is carefully cut, bearing in mind the proximity of the external popliteal nerve (Fig. 398), and is turned upward, dissecting the under surface, and the muscle and tendon are covered with gauze wrung out of warm salt solution. The second incision, about three inches in length, extends from the center of the upper edge of the patella upward and outward toward the upper end of the first wound. A tunnel superficial to the muscles but just beneath the deep fascia, is made from this wound to the first. This tunnel must be so large that there is no possibility of the muscle being caught and bound by it. A pair of large

Fig. 398.—Transplantation of tendon of the biceps femoris. Exposure of the tendon, showing proximity of the nerve. (Sir Robert Jones.)

forceps is passed through the tunnel from the second incision and the end of the biceps tendon is grasped and drawn through, taking care not to twist the muscle in this procedure (Fig. 399). The tendon of the quadriceps is split about half an inch above its insertion into the patella and the tendon of the biceps is drawn through so that its end appears on the surface of the quadriceps tendon (Fig. 400). The biceps tendon is here united to the quadriceps tendon by three sutures of tanned or chromic catgut. The aponeurosis below the tunnel is split downward as far as the upper edge of the patella and the end of the biceps tendon is sutured into this field with tanned or chromic

catgut. The skin wound is closed in the usual manner. Splints are applied to give the leg and thigh complete rest during healing.

Usually where the inner hamstring muscles are vigorous and it is not necessary to transplant tendons from both the inner and the outer side, the semitendinosus and gracilis are transplanted in preference to the biceps. An incision is begun about one inch above and a half inch posterior to the inner condyle of the femur and is carried through the skin and subcutaneous tissue parallel to the femur to about the junction of the middle and upper third of the thigh. The muscles are examined to see that they are in good condition. The belly of the semimembranosus first comes into view, then its tendon, and

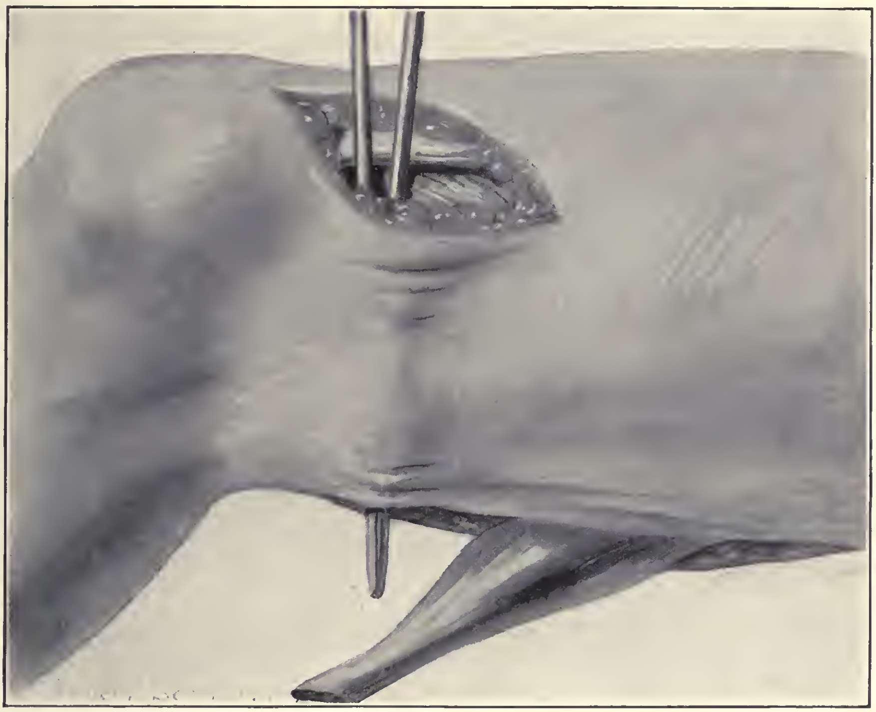

Fig. 399.—A tunnel has been made and the biceps tendon is to be drawn through to the second incision. (Jones.)

underneath this is seen the semitendinosus and the gracilis, both of which have long thin tendons and are more suitable for transplantation than the semimembranosus. The skin at the lower angle of the wound is retracted in order not to carry the incision far enough down to weaken the structures around the knee joint. The semitendinosus and the gracilis are dissected out and their tendons clamped and divided as near their insertion as possible, while retracting the lower angle of the wound. The tendons and muscles are dissected freely to near the upper angle of the wound. A second incision is made on the anterior portion of the thigh about its middle and down to the quadriceps muscle. A tunnel is made from this incision backward, connecting with the upper

portion of the first incision. The ends of the tendons of the semitendinosus and gracilis are drawn through and quilted with braided silk.

The muscle and tendon are always protected with gauze wrung out of moist salt solution while the other incisions are being made.

A third incision begins about one inch below the upper edge of the patella and is carried upward in the midline about two and one-half inches and goes through the superficial fascia and fat. A long probe, or a pair of forceps, or a tendon carrier is inserted into this last incision and makes a broad tunnel between it and the second incision. The silk having been quilted in the tendons of the semitendinosus and the gracilis, they are pulled down into the third in-

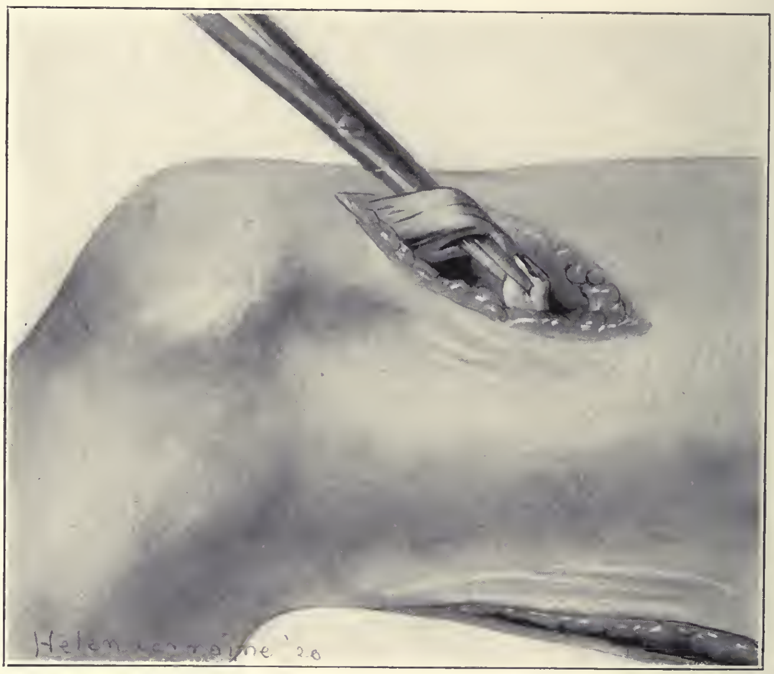

Fig. 400.—The tendon of the quadriceps has been split and the tendon of the biceps is drawn through. (Jones.)

cision and the ends of the silk are threaded into a needle and sutured to the quadriceps tendon just above the patella. The muscle tissue itself is also attached to the quadriceps muscle and tendon just above the patella after slightly scarifying the quadriceps. These sutures may be chromic or tanned catgut or silk. The ends of the silk sutures from the transplanted tendons are again threaded into needles after the silk has been tied just above the patella and are carried beneath the skin to a fourth small curved incision over the external portion of the head of the tibia. Here the silk sutures are quilted into the periosteum, tied three times, and the knot is pressed down

flat. The deeper structures are brought together by chromic or tanned catgut and the skin is closed in the usual manner with silkworm-gut or silk.

Occasionally it may be necessary to transplant both the inner and the outer hamstring muscles into the tendon of the quadriceps. Here it may be best to quilt the end of the biceps with silk, suture it into the quadriceps tendon, carry the silk down to the head of the tibia on the inner side, and quilt it into the periosteum. In the technic of Sir Robert Jones, however, he relies upon splitting the tendon of the quadriceps, drawing the biceps tendon through, and fastening it lower down with tanned or chromic catgut. Either of these methods is excellent, but the braided silk, if the knots are tied to lie flat, will probably afford a firmer insertion where on account of the paralysis it appears that the union may not be strong.

If the sartorius muscle is to be transplanted its insertion is exposed and the muscle divided near its insertion, quilted with silk at its lower end, and brought through an incision in the middle anterior surface of the thigh, as in transplantation of the semitendinosus and gracilis. The end of the muscle with the silk quilted in is brought through a wide subcutaneous tunnel from an incision just above the patella to the second incision and is sutured by the silk in the usual manner into the tendon of the quadriceps just above the patella. The silk can also be carried down and quilted into the periosteum in the midline of the tibia just below the patella. The quadriceps muscle and the sartorius are scarified and sutured together.

After all tendon transplantations the leg should be placed in such a position that there will be the least possible strain upon the tendon. Slight passive motion is begun after three weeks, but no active strain should be put upon the tendon for three or four weeks longer.

DEFORMITIES OF THE ANKLE JOINT

Before a tendon transplantation is done any defect in the joint over which the tendon acts must be corrected so far as possible. In club foot the foot must be brought to its normal or to an overcorrected position. Club foot may usually be straightened in a newborn infant by manual manipulation and holding the foot in position with adhesive plaster and straps. In older children a Thomas foot wrench or a Bradford wrench is used. The patient lies on the abdomen with the leg flexed and in this position the maximum amount of force can be most conveniently brought to bear.

A common form of congenital club foot is an equinovarus, in which the heel is drawn up and the sole of the foot is turned in. In pronounced cases the patient walks upon the dorsum of the foot. Formerly, for this type of club foot, the Phelps operation was much in vogue. This operation consisted in cutting all of the resisting structures on the inner side of the plantar surface of the foot. The original operation left a large deep raw surface which filled with granulation tissue and formed a large scar. An improvement was introduced in which a V-shaped incision was made into the skin with its base

about the middle of the sole of the foot and the apex in front of and below the internal malleolus. Subsequent manipulations, however, are likely to open the wound.

The preferable procedure is first to correct the foot as far as possible by manual manipulations or the foot wrench. When the equinovarus is extreme it may be necessary to remove a small wedge of bone from the anterior end of the os calcis and the astragalus. This is not necessary in the paralytic type of club foot. After manipulating the foot tenotomy of the tendo Achillis is done and then a subcutaneous tenotomy of the plantar fascia. If after this procedure an overcorrection is not obtained a small wedge of bone is removed from the os calcis and the astragalus through an incision just in front of the external malleolus and extending toward the base of the fifth metatarsal bone. This incision is carried down to the bone, the tendons are retracted, and the prominent part of the astragalus is exposed. A small wedge of bone is removed from the astragalus with an osteotome, which should enter

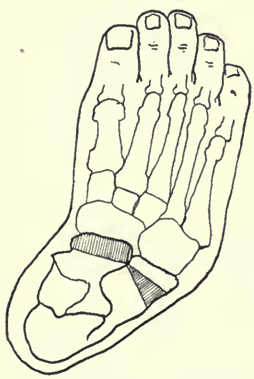

Fig. 401.—Correction of club foot by excision of bone from the os calcis and the astragalus. The bone to be excised is represented by the shaded area.

Fig. 402.—Line of incision for the operation of Ober for correction of club foot.

the bone at some distance from the tibia so as not to interfere with the ankle joint. If this proves insufficient a small amount of bone is removed from the front end of the os calcis (Fig. 401).

When the os calcis is markedly tilted the operation of Ober is indicated. Here the foot is manipulated and stretched as far as possible and an incision is made on the inner side of the tibia from two inches above the internal malleolus, curving slightly downward and forward to the scaphoid (Fig. 402). The incision is carried to the bone and the periosteum over the inner malleolus is exposed and incised transversely about one inch above the tip of the malleolus while the skin incision is strongly retracted. The periosteum is

also ineised on eaeh side of the malleolus so it ean be raised from the bone. The lower and front portions of the periosteum remain attaehed to the ligaments of the ankle joint. The periosteum and the ligaments are separated from the bone with an osteotome and this separation is earried to the ligaments of the astragalus and os ealcis and the astragalus and seaphoid until the foot can swing outward freely (Figs. 403 and 404). After loosening the upper end of these ligaments the foot is manipulated. The tendo Aehillis is eut last of all and the foot is then again manipulated, if neeessary with a wrench, in order to plaee it in an overeorrect position. The periosteum is not sutured but

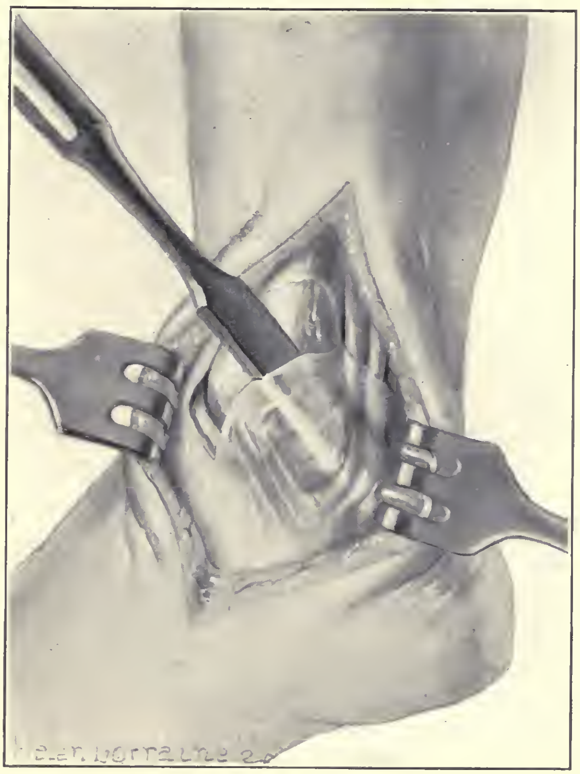

Fig. 403.—Mobilization of the periosteum and ligaments in the operation of Ober.

the deeper structures are brought together with tanned or ehromie eatgut and the skin is sutured as usual with silk or silkworm-gut. A plaster of Paris bandage is applied over the dressing. A liberal amount of wadding is used when the plaster is applied and eare is taken to prevent squeezing together the toes. It is probably best to apply plaster over the foot and over the leg separately and after these easts have slightly hardened to seeure the proper position and then apply plaster to eonnect these two segments of the east.

The equinovalgus or the ealeaneovalgus type of club foot is usually due to paralysis, while the equinovarus type is almost always congenital. In the valgus elub foot the balanee of the foot should be restored by overeorreeting

the deformity and then transplanting tendons, as has been described. When there is marked lack of stability at the ankle joint the astragalus may be excised with displacement of the foot backward. When the extensors of the toes are very active and "hammer" toes result, it may be well to transplant a tendon of the great toe into the head of the metatarsal bone and attach the other extensors to the tarsus after dividing them below. In extreme valgus, whether calcaneo or equinovalgus, with a flail joint, astragalectomy is a satisfactory procedure. The correction of the valgus may, however, be possible with the use of wrenches and the transplantation of tendons. When

Fig. 404.—Mobilization of anterior portion of periosteum and ligaments in the operation of Ober.

the bone is greatly deformed a wedge may be removed from the scaphoid or from the astragalus, followed by transplantation of tendons. Both tibial tendons may be buried into grooves in the tibia anteriorly and posteriorly, to act as internal ligaments for the joint.

In removing a wedge of bone from the scaphoid an incision is made one-half inch in front of, and the same distance below the internal malleolus and extends forward to the first metatarsal bone. The incision is carried to the bone and the tissues are dissected up and retracted in one layer. The tendons of the tibial muscles are carefully retracted. A wedge of bone is removed from the scaphoid and adjoining bone. The wedge is sufficiently

large to allow the foot to come in satisfactory position. The tissues are closed in the usual way.

Pure talipes calcaneus is usually due to paralysis of the muscles supplying the tendo Achillis and is corrected by first straightening the foot and then transplanting the tendons of the peroneus muscles into the tendo Achillis, or if the peroneus muscles are affected the posterior tibial or the flexors of the toes can be used. The operation in which this is done and an area of skin removed from the anterior part of the ankle has been described.

In "hammer" toe or "claw foot" tenotomy of the contracting tendons and stretching of the toes is usually sufficient. If it is not, however, and especially if the case is of long standing, a small piece of bone is removed and then tenotomy is done. If bone is to be excised an incision is made three-fourths of an inch long to the inner or outer side of the dorsal tendon down to the bone. The periosteum is divided and raised and the joint excised subperiosteally by dividing the distal end of the proximal phalanx and the proximal end of the second phalanx. Sufficient bone should be excised to permit free extension and flexion of the joint. The deeper tissues are sutured with fine tanned or chromic catgut and the skin is closed in the usual way. A well padded splint is applied to the whole foot and toes and a plaster of Paris bandage over this. The patient can walk with the plaster cast in about two weeks and the toes may be given freedom in two weeks longer. A broad shoe should be used.

In marked hallux valgus, particularly where there is callus formation, the deformity can be corrected by a curved incision including the callus and with the base below. This is dissected up, according to the method of C. H. Mayo, and a second flap is made of the ligaments and the bursa with its base just back of the head of the metatarsal bone. As much of the head of the metatarsal bone is excised as seems necessary to bring the toe in the proper position, taking the bone only from the inner side of the head. The flap consisting of ligament and bursa is carried over the raw surface left by excising the head of the metatarsal bone and is fastened in position by one or two sutures of tanned or chromic catgut. The U-shaped skin flap is sutured and the toe is kept in a splint for about four weeks. After that some padding is placed between the great toe and the next toe for several months and broad shoes should be used.

When the deformity is not extreme tenotomy of the extensor of the great toe sometimes affords relief when accompanied by osteotomy through the base of the head of the metatarsal bone. For this operation a longitudinal incision one inch long is made on the inner side of the tendon of the great toe and over the head of the metatarsal bone. Osteotomy is done through the head of the bone and the deformity overcorrected. A wooden plantar splint is applied.

All of the head of the metatarsal bone should never be removed as this does away with the weight bearing part of this bone, which is very important. Exostoses may be trimmed or a small wedge-shaped part of the bone removed.

If more than this is necessary instead of removing the whole of the head an osteotomy should be done. It will require considerable time for the bone to unite firmly but this operation gives much better eventual results than can be obtained by removing the head of the bone, which has a very important function.

INGROWING NAIL

An ingrowing toe nail that cannot be cured by proper care of the nail is relieved by an operation that removes about one-fourth of the nail and the adjoining soft tissues. This can be done under a local anesthetic either by infiltrating the base of the toe and blocking the nerves or by directly injecting the tissues that are to be the site of the operation. The incision begins in the soft tissues about on the level with the tip of the nail and is carried back deeply to a point about half way between the base of the nail and the next joint. Another incision parallel with this and removing about one-fourth of the toe nail is begun by inserting the point of the knife under the nail with the cutting edge upward and splitting the nail from below upward from its tip through its base. The incision is then inclined so as to meet the first in-

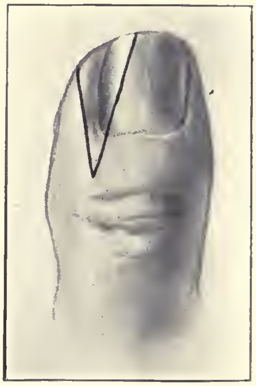

Fig. 405.—Lines of incision for operation for ingrowing toe nail.

cision at an angle (Fig. 405). The mass of tissue included by these two incisions is excised in one piece, including the soft tissues, about one-fourth of the nail and the matrix of the nail. It is quite important to remove the tissue cells that constitute the matrix of the removed portion of the nail so that here the excision of the tissue is carried down to the periosteum, as otherwise a few cells that are left will produce fragments of nail that will be painful and difficult to remove. The wound is sutured with interrupted chromic or tanned catgut in a sharp needle, the first suture being introduced at the inner angle of the wound and tied sufficiently tightly to control the bleeding. Two or three other sutures are inserted from the skin flap, bringing the needle through the nail from below upward. In this manner the nail can be easily penetrated. The

tourniquet is removed and if any spurting point is left an additional suture is placed.

THE JOINTS

In marked paralysis about the ankle when there is complete flail foot, or when the talipes cannot be otherwise corrected, the astragalus may be excised. This is done through an incision beginning back of the external malleolus and one inch above it. The incision is carried down posteriorly to the external malleolus, around its lower extremity to the middle of the anterior portion of the tarsus, and then directly down to the base of the second metatarsal bone. Another incision that may be used is a vertical incision anterior to the external malleolus. It begins just anterior to the fibula and about one and one-half inches above the tip of the external malleolus and is carried down along the inner side of the peroneus tendon. The latter incision is preferable when the operation is for marked paralysis where there is an effort to stabilize the joint, as this incision interferes but little with the circulation. The ligaments from the external malleolus are separated with an osteotome subperiosteally and strong retraction is made on the two margins of the incision. The ligaments over the os calcis and those binding the astragalus are also separated subperiosteally. The anterior portion of the incision is strongly retracted and the tissues are lifted from the astragalus and the neck of the astragalus is divided as far forward as possible. An osteotome is inserted above the astragalus, between it and the tibia, and while the foot is adducted the astragalus is cut down upon vertically leaving a flat portion of the astragalus next to the internal malleolus. The body of the astragalus is in this manner easily removed as the foot is dislocated inward and the small portion that has been left attached to the internal malleolus can be removed with the osteotome and forceps. After the removal of the astragalus the foot is displaced inward to expose both malleoli and any tissue that prevents the backward displacement of the foot is removed or corrected. The foot is then displaced backward.

In a flail joint silk may often be inserted and the joint thus held moderately stiff. This may be done by an open or a subcutaneous method. Silk ligaments are particularly useful at the ankle to prevent toe dropping, which is a result of paralysis, and they also increase the lateral stability of the joint. The silk ligaments may be placed in an open operation. Here the incision is made over the anterior part of the lower third of the tibia, cutting down to the periosteum, which is incised and stripped up. The silk is quilted in the two edges of the periosteum and a second piece of silk is tied to the two ends that have been quilted. This gives four strands. A curved incision is made over that part of the foot in which the silk is to be inserted and the silk is carried subcutaneously to this incision. It is then quilted in and tied, two strands being used on the inner side and two on the outer side of the foot. Usually the inner incision is made over the scaphoid and internal cuneiform

bones and the outer over the cuboid. The ligaments, as well as the periosteum, are caught in the quilting suture.

Bradford uses the subcutaneous method and begins at a point on the lower third of the tibia. The skin over the bone is retracted so as not to be in its normal position and a drill with an eye at the point is passed through the skin and the tibia. As it emerges from the bone the skin is pulled forward before the drill perforates it (Figs. 406 and 407). This procedure prevents the opening in the bone being opposite the puncture in the skin. The two ends of a silkworm-gut strand are passed through the eye of the drill and the drill is withdrawn. Braided silk is caught in the loop of the silkworm-gut

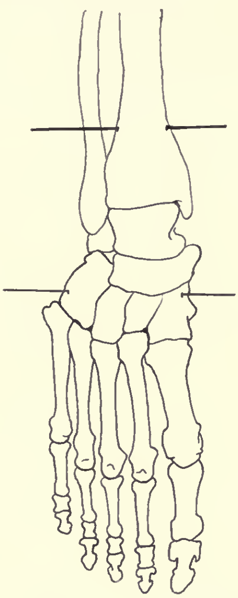

Fig. 406.—Insertion of braided silk for correction of flail ankle joint. The diagram shows the position of the drill holes in the bone. (Method of Bradford.)

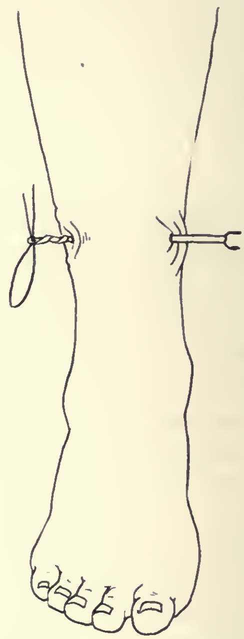

Fig. 407.—The drill has entered the tibia. (Bradford.)

suture and drawn through. In a similar way the tarsal bones are drilled from within outward, pulling the skin to one side, and drawing through a doubled strand of silkworm-gut (Fig. 408). The silk used is very heavy braided silk, which is first carried through the hole in the tibia. The outer end of the silk is then passed subcutaneously to the loop of silkworm-gut through the tarsus and is thus drawn through the tarsus (Figs. 409 and 410). Then by a carrier the end of the silk that comes through the inner hole of the tarsus is carried subcutaneously to the end of silk that has been left at the inner hole in the tibia (Fig. 411). The silk is tied firmly in three knots, the ends are cut, and the skin is drawn over the knots (Fig. 412). Strips of fascia lata are sometimes used instead of silk ligatures.

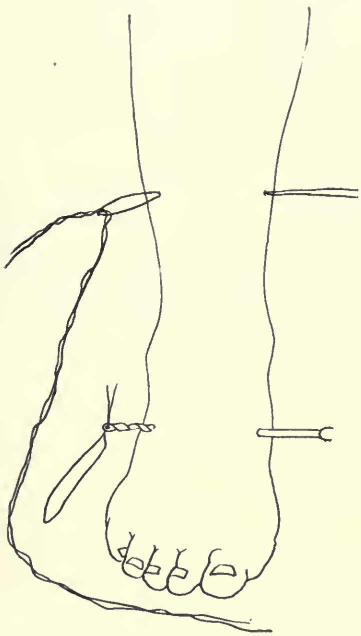

Fig. 408.—The drill hole in the tibia has been made and the silk is being pulled through. (Bradford.)

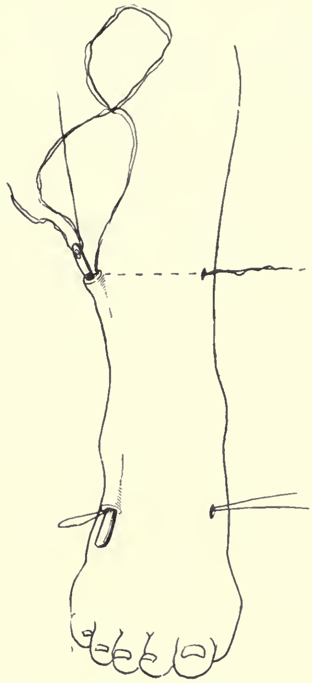

Fig. 409.—A tunnel has been made on the outer side of the foot, and the silk is being pulled through the tunnel. (Bradford.)

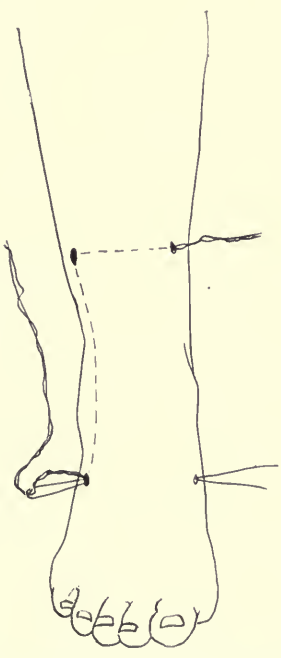

Fig. 410.—The loop is being pulled through the drill hole in the tarsus. (Bradford.)

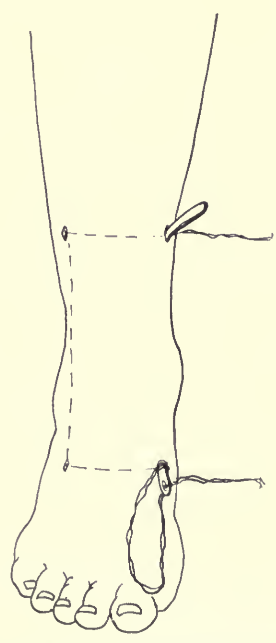

Fig. 411.—A tunnel has been made on the inner side of the foot and the second end of the silk is being pulled through to the first end.

Excision of the ankle joint is not often necessary, but may be done through a transverse curved external incision which begins on the dorsum of the foot midway between the ankle joint and the articulation of the astragalus and scaphoid. The incision is carried backward horizontally below and beyond the external malleolus, and then up between the tendo Achillis and the tendons of the peroneus muscles to a point about three inches above the joint (Fig. 413). The superficial peroneal nerve should be identified and retracted out of the way. The extensor tendons and the tendons of the peroneus muscles are retracted inward and the sural nerve and the small saphenous vein are protected behind. The incision is carried down to the fibula and the astragalus and divides the capsule of the ankle joint back to the external

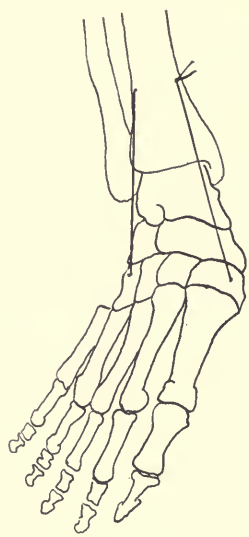

Fig. 412.—The knots have been tied. The position of the silk in the skeleton of the foot and leg is shown in the diagram.

malleolus. The bands of the external lateral ligaments are separated from the external malleolus. The sheath of the peroneus tendons is incised posteriorly to the fibula. The tendons are removed from the sheath and retracted backward by splitting the sheath of the tendons high up. It will be unnecessary to divide the tendons if they can be retracted. Sometimes, however, they must be divided. The periosteum is incised over the fibula and separated along with the adherent peroneus sheath from the posterior surface of the fibula and tibia. The periosteum is separated from the anterior surface of the fibula and tibia, which also removes the attachment of the capsule of the joint in this region where it is adherent to the periosteum. The foot is bent forcibly inward until it is completely displaced and the inner side of the foot rests against the leg turning on the internal lateral ligament as a hinge. As much of the bone is removed as is necessary. It is particularly desirable to saw off no more bone from the astragalus than may be necessary and small separate

foci should be chiseled out and not curetted. In this manner healthy bone around the focus is cut with a chisel and the focus is thus removed, whereas the curet often forces diseased tissue further into healthy bone. After a sufficient amount of bone has been removed the peroneus tendons are sutured, if it has been necessary to divide them, or simply replaced in their sheaths, if they have been preserved.

Excision of the astragalus for disease of the bone or joint may be done by an external curved incision, or by an external angular and internal curved incision. The external curved incision begins about three inches above the ankle at the anterior border of the fibula and is carried down external to the peroneus tertius tendon and superficial peroneal nerve and then curves forward over the outer portion of the astragalus to the base of the fifth metatarsal bone. The peroneus tendon is retracted inward and the extensor brevis digitorum is retracted outward. In the space thus exposed the capsule of the ankle joint is incised and the neck of the astragalus and the lower ends of the

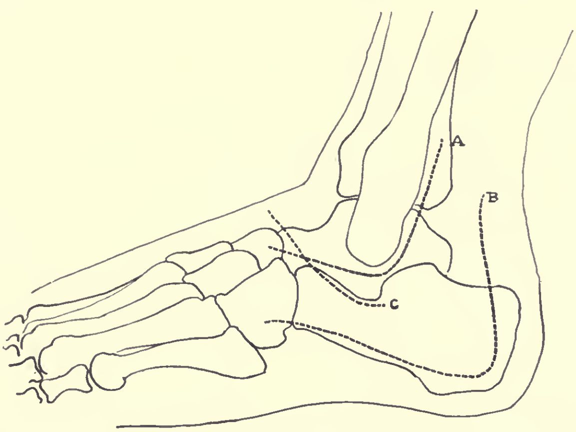

Fig. 413.—Lines of incision for: *A*, excision of ankle joint (method of Lauenstein); *B*, excision of os calcis (Ollier); *C*, excision of astragalus (Ollier).

tibia and fibula are freed. The calcaneo-astragaloid ligament and the anterior and posterior bands of the external lateral ligament are divided. The attachment between the astragalus and os calcis and scaphoid are cut with a stout knife and the foot is inverted forcibly and the inner surface of the astragalus is freed as much as possible, taking care to avoid injury to the posterior tibial vessels and nerves. The astragalus is removed with bone forceps, any further attachments being divided with scissors. The ends of the ligaments should be brought together with chromic or tanned catgut and the skin closed in the usual manner.

In intractable club foot, particularly the type that has recurred after operation, the bony structures of the foot are often so deformed that even correction of the soft parts does not give the desired results. Here the method of bone grafting employed by Albee may be utilized. In order to see the structures satisfactorily it is necessary to use an Esmarch and a tourniquet.

The tendo Achillis is divided in the usual manner, the contracted plantar fascia is cut subcutaneously, and the foot is forced into as good position as can be attained. In the type of club foot in which bone grafting is indicated methods such as this with the use of manual force and the foot wrench have already resulted in recurrence, so bone grafting must be done and a U-shaped incision is made on the inner and upper portion of the foot with the base of the flap posteriorly. The upper line of the flap begins in front of the middle of the ankle joint and the incision is carried forward on the dorsum of the foot almost to the tarsometatarsal joint where it curves downward and inward across the base of the first metatarsal bone and then is carried back to a point just below and in front of the internal malleolus. This flap, including subcutaneous tissue, is turned back and exposes the scaphoid bone. The bone is split with a thin osteotome into two halves (Fig. 414). The foot is then forced into overcorrection, which widens the gap in the scaphoid (Fig. 415). Any soft tissues that are markedly resisting the over-

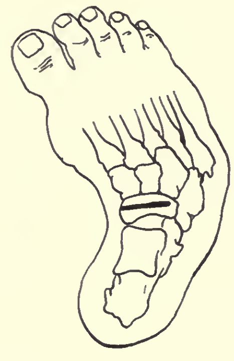

Fig. 414.—Incision for bone grafting in intractable club foot.

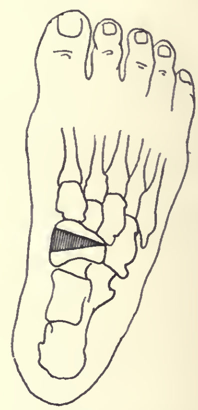

Fig. 415.—Club foot has been straightened and is ready to receive the bone graft.

correction of the foot are divided. The gap in the bone is measured with calipers and after exposing the inner surface of the tibia by an incision in the skin and turning back the periosteum, a wedge of bone is cut from the internal surface and the crest of the tibia by a motor saw. A thin osteotome can be used for this but a motor saw is preferable. The base of the wedge is at the crest of the tibia and the apex is directed inward and toward the medullary cavity. A hole is drilled in the base of the wedge before it is removed so that it can be fixed in its new position with a suture. It is easier to drill the hole before the wedge is entirely free. The wedge of bone is immediately transferred to the gap in the scaphoid and should fit so snugly that it prevents the recurrence of bony deformity. The edges of the scaphoid are drilled and kangaroo tendon is passed through the hole in the scaphoid and the hole in the graft and tied so as to hold the graft in position. A bone peg may be utilized for this purpose. When the graft has been inserted and fixed the foot should remain in this overcorrected position after it has been released.

Usually the overcorrection makes it impossible for the flap to be sutured to cover the whole wound, but it will at least cover the grafted bone and the rest of the wound must be left to heal by granulations, or to be closed by a plastic procedure later on. A few layers of smooth gauze are placed between the toes, the foot is dressed, and plaster of Paris applied over the foot to hold it in the overcorrected position, the knee being flexed to almost a right angle, and the plaster cast extending to about the middle of the thigh. Soule has modified this operation by mortising a piece of bone between the divided halves of the scaphoid.

If the method of inserting silk ligatures does not secure satisfactory arthrodesis, the joint surface should be exposed as in excision and the cartilaginous surface removed from the joint. Albee advises, after exposing the ankle joint, the removal of the astragalus without fracturing it. The cartilaginous surfaces of the astragalus are cut away with a motor saw and the astragalus is denuded of its periosteum and replaced in the ankle after the cartilage has been removed from the adjoining surfaces of the scaphoid, os calcis, tibia and fibula. Here the astragalus acts practically as a bone graft and makes bony ankylosis of the ankle joint almost certain to result.

Dislocation of the patella is usually remedied by splitting the tendon of the patella as advised by Goldthwait. The displacement is almost always outward and while it is easily reduced, the inner portion of the capsule has become stretched and there is a tendency to recurrence of the dislocation. An incision is made to the inner side of the median line extending from near the middle of the patella downward for about three inches. The edges of the wound are retracted and the tendon of the patella is exposed, raised, and split longitudinally. The lower end of the outer half of the tendon is detached subperiosteally from the tibia, brought under the inner half, and reattached by quilting sutures to the periosteum on the inner portion of the head of the tibia. This prevents the tendon from sliding outward.

Displaced semilunar cartilages are more frequent on the inner side than on the outer. The knee is flexed at a right angle, preferably at the end of the operating table according to the method of Sir Robert Jones with the leg and foot hanging down from the table. An incision is made going downward about half an inch to the inner side of the patella to the tibia and then curving at a right angle along the upper portion of the inner head of the tibia for about two and a half inches. The tissues are dissected and retracted as a flap down to the capsule of the joint. The fibers of the capsule are incised without opening the synovial membrane. This membrane is then incised parallel to the head of the tibia. The inner semilunar cartilage is elliptical in shape and slightly thicker than the external semilunar cartilage. If the cartilage is loose it can be lifted with a pair of forceps and dissected free with scissors from its attachment. It is important not to cut the lateral ligament of the joint. All of the cartilage except a small part of the posterior portion is removed. The bleeding is checked by pressure of cotton sponges and by whipping over the synovial membrane with a continuous catgut suture.

No knots or exposed sutures or ligatures should ever be left within the joint. The capsule is brought together with tanned or chromic catgut and the skin united in the usual manner.

Exposure of the knee joint for removal of foreign bodies, or for removal of a tumor, or inspection of the knee, is satisfactorily done by splitting the patella into two halves, or by the bayonet incision. Sometimes two lateral incisions may be used. The splitting of the patella gives the fullest view of all the pouches and culdesacs of the joint and of any repair work on the crucial ligaments that may be necessary. The incision begins slightly to the inner side of the midline about four inches above the patella and extends downward over the patella slightly to the inner side of the midline to a point below the insertion of the patella tendon. The tendon and the patella are exposed and the tendon above the patella is split slightly to the inner side of the midline, and then is split below the patella. The leg is held straight and the patella is sawed about two-thirds through when the knee is flexed to about forty-five degrees and the division of the patella is completed with a sharp osteotome. The patella is divided slightly to the inner side of the midline, because there is less mobility of the inner fragments than the outer and better exposure can be obtained in this way, as the tendons both above and below the patella are also split a little to the inner side of the midline. The synovial membrane is opened above the patella, laying bare the upper culdesac. The knee is then flexed about ninety degrees and the halves of the patella are retracted strongly while the patella ligament is completely split and the fat beneath it divided. Any foreign body or tumor is removed, or repair work is done upon the crucial ligaments if necessary. The wound is closed by adjusting the two halves of the patella carefully and suturing the fascia and the split tendons together so as to hold the patella firmly approximated. These sutures are best made of tanned or chromic catgut. It is not necessary to place sutures in the patella itself. The leg should be dressed in a posterior splint or with plaster of Paris and gentle passive motion of the patella is begun about the seventh day.

The knee may be also exposed anteriorly by the bayonet incision, which begins on the inner side of the patella about two inches above it, is carried down, then across the ligamentum patellæ about half an inch below the lower border of the patella and then goes down along the outer margin of the ligamentum patellæ. The cross incision should not be made at a right angle so that the ligamentum patella can be more readily repaired. This incision requires longer for the ligamentum patella to repair and may leave this ligament somewhat weak.

If loose bodies are located in the back of the joint a posterior incision may be made. Here a long vertical incision is made posteriorly in the midline beginning about three inches above the joint and ending two inches below it. Dissection is carried down to the joint with care, avoiding the popliteal vessels and nerves. This incision is very seldom necessary.

Excision of the knee joint is best done by a slightly curved anterior incision, though a U-shaped incision with its base upward, or an H-shaped incision can be used. The U-shaped incision has the disadvantage of poor nutrition at the tip of the flap, which is also an objection to the H-shaped incision. The curved anterior incision begins at the posterior portion of one of the condyles of the femur, about half an inch above the lowest articular surface, is carried forward and slightly downward across the lower portion of the knee and just above the insertion of the ligamentum patellæ and ends at the posterior portion of the opposite condyle of the femur. This incision is made while the knee is slightly flexed and is carried through the ligamentum patellæ and the capsule of the joint, dividing the ligamentum patellæ about half-way between its insertion into the tibia and the patella. The patella and the tissues of the upper flap are retracted upward and the joint is further flexed while the crucial ligaments are divided. The flaps are retracted, the knee joint is acutely flexed, and a section is sawed from the femur, particular care being taken to guard the popliteal vessels. The femur is held perpendicular and the saw is applied just above the articular line and so far as possible about parallel with the lower plane of the articular surface of the condyles. The articular surface of the head of the tibia is next sawed. The sections are so sawed that the bone surfaces when brought together will make a flexion of the knee of about ten or fifteen degrees. This is much better than having an absolutely straight leg. It is important not to remove too much bone. If most of the disease is removed the other foci can be chiseled out. It is important not to use a curet as this may force septic material into otherwise healthy bone. The patella is left if it is healthy, or if slightly diseased its articular surface may be removed by a saw or chisel while it is held in bone forceps. The culdesac under the quadriceps tendon is explored and the synovial membrane dissected away. The bone is brought together and fastened in position by sutures of stout kangaroo tendon through the bone along the margins of the incision and by suturing the capsule and fascia with tanned or chromic catgut. The divided ligamentum patellæ is sutured with chromic catgut.

An excellent method of immobilizing the surfaces of the bone after excision of the knee joint is the inlay graft of Albee, the technic of which has already been described. This makes bony union more certain and it may be used when it would otherwise appear necessary to remove a larger section of bone. It must be recalled that the more bone removed from the femur above the condyles the narrower the weight bearing surface and consequently the greater are the mechanical difficulties of stabilizing the joint. It is the practice of some surgeons to fix the bones together by metal nails or screws. These are very likely to give trouble afterwards. Irritating metals, such as iron, cause an osteoporosis around the metal, and so retard union. If the bone cannot be held securely by stout kangaroo tendon it will be best to insert bone pegs, which are made from strips of adjacent

bone by the electric doweling instrument. The inlay graft method of Albee not only holds the bones in position but adds to the strength of the callus.

The hip joint may be excised by the external straight incision of Langenbeck, the anterior straight incision of Barker, or the posterior angular incision of Kocher. The external straight incision begins over the ilium about three inches above the upper limit of the great trochanter and is carried down five inches in the long axis of the femur just behind the center of the outer surface of the great trochanter, terminating below the base of the great trochanter. The incision after going through the skin and fascia divides the gluteus maximus muscle almost in the line of its fibers. The space between the gluteus medius muscle in front and the pyriformis muscle behind is identified, widened by retraction, and the capsule of the joint together with the periosteum of the great trochanter is incised longitudinally to the bone. The capsule may be further divided by a transverse cut. The capsule with the periosteum is raised with a periosteal elevator and the cotyloid ligament is divided by inserting a stout knife between the head of the bone and the cotyloid ligament and cutting toward the edge of the acetabulum. In this manner the atmospheric pressure on the joint is overcome. If there is difficulty in doing this a portion of the rim of the acetabulum is chiseled away. The attachment of the muscles to the outer and posterior surface of the great trochanter is raised subperiosteally if possible while the knee and foot are twisted to rotate the thigh inward and then to rotate the thigh outward. The ligamentum teres is divided and the head of the bone dislocated by manipulation of the thigh. The upper end of the femur is cleared of the soft parts and held with stout forceps while the head of the femur is sawed off below the great trochanter. There should be a slight obliquity from above downward and inward. The acetabulum is cleared by a chisel and the pockets of synovial pouches are removed. A drainage tube is inserted. The capsule and muscles are sutured with chromic or tanned catgut. The limb is placed in extension.

The anterior incision for excision of the hip joint begins about half an inch below the anterior superior spine of the ilium and goes downward about four inches between the rectus and sartorius muscles on the inner side and the tensor vaginæ femoris and gluteal muscles on the outer side. The lateral femoral cutaneous nerve is retracted outward and so avoided. The intermuscular plane between the muscles mentioned is followed and the muscles are retracted outward and inward respectively. The branches of the external circumflex will require ligation. The joint is reached without the actual division of any other muscle, vessel, or nerve of consequence. The capsule is incised over the front of the joint in the line of the incision and down to the head of the femur. The cotyloid ligament is cut to admit air and the neck of the bone is divided with a narrow finger saw or with a wire saw while retracting the soft parts. The head of the bone is seized with forceps and twisted out of position after dividing the ligamentum teres.

The cavity of the acetabulum is cleared of any diseased material and the capsule is sutured after instituting drainage.

The posterior angular incision of Kocher begins at the base of the great trochanter, is carried upward and forward to the anterior angle of the great trochanter, and then obliquely upward and inward in the line of the fibers of the gluteus maximus muscle. The aponeurosis of the gluteus maximus muscle over the external portion of the great trochanter is divided and the fibers of this muscle are divided in the upper part of the wound where the branches of the gluteal artery must be cut and tied. The interval between the gluteus medius and minimus above and the pyriformis muscle below is identified and retracted and the posterior part of the capsule and of the acetabulum is exposed. The capsule is divided along the upper border of the pyriformis muscle. The femur is rotated outward and the insertion of the gluteus medius is separated subperiosteally from the bone externally and the insertion of the gluteus minimus is similarly separated from the bone along the anterior border of the great trochanter. The insertion of the pyriformis, internal obturator, and the gemelli muscles is similarly separated from the great trochanter and the insertion of the obturator externus into the digital fossa is raised subperiosteally or by a chisel. The thigh is rotated inward and the inner and back portions of the great trochanter are freed. The cotyloid ligament is divided to admit air. The ligamentum teres is cut from behind on the head of the femur while the thigh is adducted and rotated inward. The head is then dislocated into the wound and removed.

OSTEOTOMY

Osteotomy is often necessary to overcome deformities in the leg or knee. It is performed with an osteotome or a saw. If an osteotome is used there should be a set of at least three different thicknesses. It is important to bear in mind that an osteotome has a point that is wedge-shaped and not beveled solely on one side as a chisel. The osteotome of Macewen is a standard in this respect. If a saw is used it should be either the small finger saw or else a Gigli wire saw. The Adams saw has a narrow cutting surface and is shaped somewhat like a rather stout tenotome with the saw teeth occupying the cutting portion of the instrument. The handle is large, as in an ordinary saw, so the instrument can be manipulated firmly. Jones' saw has a small button on the tip of the saw which will somewhat protect the soft tissue. The Gigli wire saw surrounds the bone completely. Through a small incision it is difficult to protect the soft tissues. The circular motor saw is often used with considerable advantage, especially in cuneiform osteotomy, when the bone can be readily exposed.

Linear osteotomy is often performed by what is known as the subcutaneous method; that is, through a very small incision. Here the section of the bone is guided largely by the sense of touch with the point of the osteotome. If a wedge-shaped area is removed the exposure of the bone should be ample

and the operation done by sight. There is not the same objection to a longer incision that formerly obtained, and even the linear osteotomy can often be more satisfactorily done by an incision sufficient to use the sense of sight as well as of touch. In linear osteotomy, as performed by Macewen for knock knee, the outer side of the knee and the lower part of the femur rest on a sand bag which is not too tightly filled. A longitudinal incision is made on the inner side of the thigh, beginning half an inch in front of the tendon of the adductor magnus muscle and about one-half to three-fourths of an inch above the adductor tubercle. A long scalpel is inserted directly to the bone and cutting upward makes an incision down to the periosteum just large enough to admit the large osteotome. The osteotome is inserted beside the knife down to the bone and after it has reached the bone it is turned transversely. The edge of the osteotome is passed over the bone until it reaches the posterior portion of the internal border and is driven in from behind forward and outward. After the cortex of the bone is penetrated a finer osteotome is passed into the wound in the bone alongside the osteotome already in position. The wider groove left by the first osteotome readily admits the second one which is thinner. The femur is bent with a little force and the portion of its cortex that remains undivided is broken. The osteotome should never be removed from the bone until the section is complete and it is best to shift its position slightly after each blow of the chisel to prevent it from becoming bound. The osteotome should be driven in such a manner that it points toward the surgeon and not away from him, as in this way it can be handled more satisfactorily. It is moved up and down after each blow of the mallet in order to widen the cut. The internal and posterior surfaces of the bone are first divided and then the osteotome is driven forward and outward, toward the front of the bone. The outer part and a portion of the posterior surface remain undivided and are fractured. After withdrawing the osteotome the wound is sutured and dressed and the limb is put up in slightly overcorrected position in plaster of Paris. This is the typical operation of Macewen for knock knee.

Cuneiform osteotomy requires a longer incision so the bone can be completely exposed. Indeed there is no serious objection to a long incision in the linear osteotomy. If cuneiform osteotomy is done over the head of the tibia the incision is made and the periosteum is reflected with the soft parts. The osteotome outlines the base of the wedge in the cortex of the bone. The base should correspond with the angle of greatest deformity and should be somewhat smaller than appears to be necessary as it is easy to enlarge it if it is actually too small. The whole thickness of the bone is not cut through. After the wedge has been removed and the limb straightened if a sufficient amount of bone has not been removed, more can be chiseled away.

Osteotomy by a saw is usually done in the neck of the femur. A long narrow-bladed knife is inserted about half an inch above the tip of the

trochanter major, and pushed inward and downward until it strikes the neck of the femur over which it is passed at a right angle to the axis of the neck of the femur, the route being about parallel to Poupart's ligament. The knife is left in this position and an Adams or Jones saw is passed along

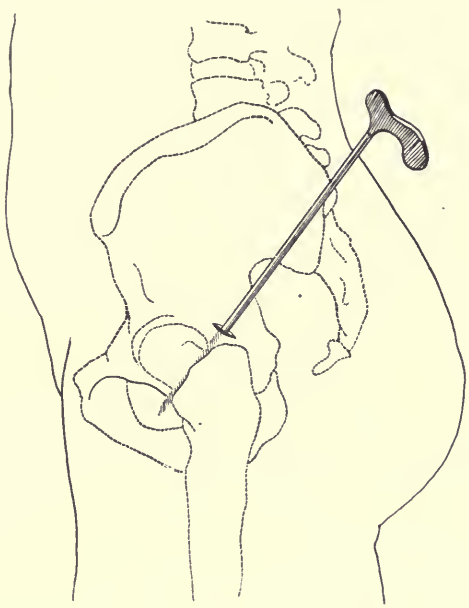

Fig. 416.—Osteotomy of the neck of the femur with the saw.

the side of the knife until the saw touches the neck of the femur. The knife is then removed and the bone is divided with a saw (Fig. 416). The saw should not be withdrawn until the bone has been completely severed.

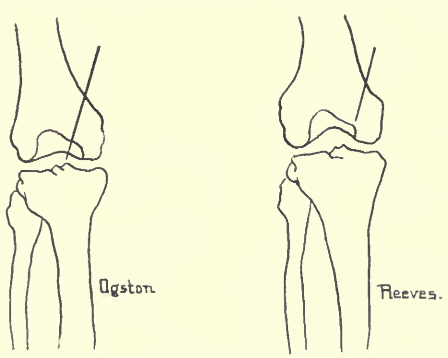

Fig. 417 Fig. 418

Fig. 417.—Osteotomy of the internal condyle of the femur for knock knee. (Method of Ogston.)
Fig. 418.—Osteotomy of the internal condyle of the femur for knock knee. (Method of Reeves.)

In knock knee the operation must be made to suit the deformity. The Macewen operation, which has been described, is satisfactory when the deformity is in the lower porton of the femur. If the deformity is due to enlargement of the internal condyle it may be corrected either by Ogston's

operation (Fig. 417) or by Reeves' modification (Fig. 418). In Ogston's operation the knee is fully flexed and a long narrow-bladed knife is inserted through the skin about two or three inches above the tip of the internal condyle. The knife is pushed downward, forward and outward until its point is in the intercondyloid space when the knife is turned with the edge toward the bone and is withdrawn, cutting the soft structures to the bone. An Adams saw is introduced through the knife wound and divides the inner condyle from above downward to about three-fourths of its thickness. The leg is straightened. Fracture of the internal condyle is completed as the leg is straightened and the condyle slips upward. Macewen makes a cuneiform osteotomy at this point when the defect is due to an elongated internal condyle. Osteotomy of the tibia is made at its most prominent deformity and is usually a cuneiform osteotomy. Where exposure is easy the circular electric saw can be used instead of the osteotome.

ARTHROPLASTY

Reconstruction of an ankylosed knee or hip joint has been advocated by the late John B. Murphy. These operations, however, have not proved satisfactory in the knee for the joint loses much of its stability and the fascia that is interposed is often absorbed from pressure and ankylosis results. In the hip joint it is doubtful if sufficiently satisfactory results are not obtained by one of the types of osteotomy already described. Large special instruments for boring out the acetabulum are necessary.

The operation upon the knee joint, according to Murphy, was done principally through a long external incision from a point six inches above the knee joint to three inches below. It is carried down to the deep fascia, but not through it except over the joint itself. A four inch vertical incision is also made over the inner side of the knee joint. The patella is freed by scalpel or chisel, but the quadriceps tendon or the ligamentum patellæ is not divided. The lateral ligaments of the knee joint are thoroughly divided and removed. If the ankylosis is marked and is bony the bone is divided with a chisel or saw and the ends of the femur and tibia are so shaped that the lower end of the femur is convex and the upper end of the tibia is concave from before backward. A large flap of fascia lata with a thin layer of muscle attached is dissected from the outer side of the thigh through the external incision with the pedicle below. The flap is sufficiently long to pass through the joint and to envelop well the lower end of the femur. It is spread over the lower end of the femur and fixed in position with a few catgut sutures. A similar but smaller flap is passed between the patella and the femur. The wound is closed using a small drainage and the leg is immobilized in plaster. Passive motion is begun after a week. Most cases of this type result in ankylosis, though there may be an occasion in which the operation is justifiable.

In arthroplasty on the hip the results have been somewhat more satisfac-

tory than on the knee, though it is seldom that the indications for this operation are apparent. In Murphy's technic a V-shaped incision is made with the trochanter about the center of the V. The base of the flap is five inches wide and is about four inches above the trochanter and the point about two inches below the trochanter. The flap is dissected through the skin, superficial fascia and fascia lata and retracted upward. The base of the trochanter major is divided transversely by a Gigli wire saw or an osteotome and the severed trochanter with the attached muscles is retracted upward. The capsule of the joint is incised and separated completely from the ilium around the joint; then the head of the femur is chiseled from the acetabulum, beginning at the line of junction and saving as much of the head of the femur as possible. After freeing most of the head the small remaining portion may be fractured. The chisels are large curved chisels, such as carpenters use, and should correspond to the curve of a normal head of the femur. The acetabulum is deepened by rongeur forceps and chisel or by an especially constructed large burr, which reams out the cavity. The fascia lata which was turned up with the V-flap is dissected from the skin, placed in the acetabulum, and held in position by a few interrupted sutures of chromic catgut. The head of the femur is so shaped and smoothed by rongeur forceps or by a concave reamer that it will fit loosely into the acetabulum before the flap of fascia lata is turned down, and snugly after the fascia lata has been placed in position. Every part of the new articulating surface is covered with fascia. It takes only the part of the flap near the base to line the acetabulum and the apex is used to cover the femur. This is also fastened in position by interrupted catgut sutures inserted into the periosteum of the neck of the femur and into the edges of the fascial flap. The trochanter major is then returned and fixed in position by a wire suture or a bone peg. The wound is closed and the leg placed in extension. It may be necessary before closing the wound to do a tenotomy on the tendons and muscles that are too greatly contracted to permit the thigh being placed in its natural position.

OSTEOMYELITIS

The type of operation for osteomyelitis depends largely upon the stage of the inflammation. Many limbs have been needlessly sacrificed, because the diagnosis of rheumatism or growing pains has been made and persisted in until there has been extensive damage. The x-ray is the greatest help in making an early diagnosis because as it has already been pointed out in discussing surgery of the bones, irritating substances cause a rapid absorption of lime salts for it is nature's effort to remove this rigid material which is an obstacle to the hyperemia that is necessary to combat inflammation. Bone, therefore, is converted as nearly as possible into soft tissue so that multiplication and dilatation of the blood vessels may be unhampered by any rigid structure. The x-rays should in the early stages show a light spot where the inflammation has begun. Any child who, after a slight injury

or exposure to cold, has marked pain near the knee or ankle, particularly if there is a chill or fever, should be regarded as at least suspicious of having osteomyelitis and if the roentgenogram confirms the suspicion, operation should be done as soon as possible. It is well to mark the point of greatest tenderness before giving an anesthetic.

In order to recognize the structures it is best to use a tourniquet. A free incision is made over the affected bone, taking care to avoid opening into the neighboring joint. Due regard is paid to vessels and nerves. The subcutaneous surface of the tibia is the best place for the incision in the leg. In the thigh the outer portion of the thigh in front of the biceps tendon or between the biceps tendon and the iliotibial band is the preferable area for incision. In very early stages there will be no marked change in the tissues over the bone, or in the periosteum, except an increased hyperemia, but soon after the beginning of the disease the tissues become edematous and the periosteum is thickened, soft, and frequently loosely attached. After separating the periosteum from the bone over an area of about an inch, the bone is carefully examined for evidence of perforation and a grooved director is passed around the bone to the popliteal space, if the femur is being explored, as often pus collects in this region. With a burr or a drill the cortex of the bone is perforated and the medulla is opened near the epiphyseal line. Usually pus will be recognized after the cortex has been penetrated; but if not, the opening in the cortex is sufficiently enlarged with rongeur forceps to enable the surgeon to explore the bone more thoroughly. Injury to the epiphyseal cartilage must be avoided. As soon as pus is discovered the focus is removed with a curet and the cavity of the bone filled with pure carbolic acid, which is permitted to stand for about a minute and is then washed out with alcohol. Drainage is best accomplished with a rubber tube, together with loose packing of iodoform gauze. A dressing and a splint are applied.

If no focus is found it is best to make provision for drainage because it may be probable that the focus is present but has not been discovered and the drainage will prevent tension and attract the inflammatory process to itself because of the effort to extrude the drainage by the lymphatic current. In later stages pus is often found under the periosteum, but this merely means that there has been extension from the osteomyelitis. Suppurative periostitis without an external wound is exceedingly rare and in the vast majority of cases the cause of the pus is from inflammation within the bone. After cleaning away the pus under the periosteum a fistula that may lead within the bone is sought for and if it is impossible to find it, or if it is impracticable to follow it, the bone should be opened as has already been described.

In the later stages of osteomyelitis there may be an extensive amount of destruction of the bone, and an involucrum results; or the infection may be mild and the resistance of the patient effective and, consequently, the inflammation will be located in a small area with comparatively little destruction of

the bone. Here the bone is opened after exposing and retracting the periosteum, the diseased bone is removed by a chisel and the wound disinfected with pure carbolic, which is left for a minute and then removed and the wound flushed with alcohol, and cleaned with peroxide of hydrogen. In such instances the wound may be dried and filled with a plug or filling. It is essential, however, that the cavity of the bone be dry. The tourniquet should, of course, remain in position during the operation. The cavity of the bone is dried with gauze sponges, or better still, by a hot air blast. If the hot air blast is not available the actual cautery can be held in the cavity, though not in contact with the bone for this will cause more dead bone. After the cavity has been thoroughly dried Mosetig-Moorhof's filling is melted and poured in up to the level of the periosteum. The periosteum is brought together loosely with sutures of catgut after the plug has become partially solidified. The subcutaneous tissues are sutured with catgut, and the skin with silkworm-gut.

The Mosetig-Moorhof plug, which seems to have stood the test better than any of the substitutes, is made as follows: The proportions consist of 60 parts of iodoform, 40 parts of spermaceti and 40 parts of oil of sesame. These ingredients are mixed and slowly heated to 212° F. on a water bath and then allowed to cool while being shaken. When ready for use the mass is heated to about 122° F., which melts it, and is constantly shaken or stirred to keep the iodoform equally distributed. The heating should be done by placing the container in hot water. The melted mass is poured into the wound at about 115° to 120° F., the leg or thigh being held in such a position that the margins of the wound in the bone will be horizontal. Care must be taken before applying the plug that every recess of the diseased bone has been cleansed and dried, as well as disinfected. This filling is not suited for acute osteomyelitis, because here the reaction of tissue is so great and the infection is so virulent that nothing short of drainage will be adequate. After drainage for a few weeks, however, the Mosetig-Moorhof plug can often be used to fill the cavity. Frequently some of the plug is extruded between the lines of sutures, as the cavity fills in with granulations. Occasionally this does not happen and the wound heals superficially, the bone plug being gradually absorbed. For months and years afterwards, during the absorption of the plug, traces of iodine can be detected in the urine. This does not apparently injure healthy kidneys, but if any nephritis was present before the osteomyelitis occurred there might be some danger in using the plug, and here packing with gauze is probably the best treatment.

Aside from any other consideration the use of a bone filling saves the patient many dressings and considerable pain and results in a more symmetrical bone, even if part of the filling is extruded, as frequently happens. It merely requires a superficial dressing and this is a great advantage over the almost daily packing of a deep and tortuous wound in the bone.

If a considerable mass of bone has been killed by the inflammation a

sequestrum forms and around it is built up layers of living bone, which enclose the sequestrum, and this is called the involucrum. If the operation is done in the early stage and the pressure that accompanies inflammation is removed before the septic products are scattered extensively through the medullary cavity of the bone, the formation of a sequestrum may be prevented unless the infection is very virulent or the patient's resistance is at a low ebb. If a sequestrum, however, has formed, the time for operation for its removal should be chosen with considerable care. During the very acute stages, even if a sequestrum is forming, operation is unwise except to relieve pressure and institute drainage, because the raw surfaces of the bone that are necessarily left after an operation will become infected from the inflammation and the destruction of more bone will of necessity be repeated. After the virulence of the inflammation has subsided, and particularly if the dead bone is well separated from the living bone, operation should be performed as soon as possible, because the continued presence of the dead bone merely acts as a refuge and a culture medium for bacteria and septic products.

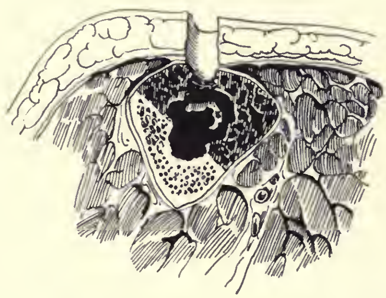

Fig. 419.—The dark portion of the involucrum shows the part to be removed in order to avoid cavity formation in the bone.

In chronic cases, when the involucrum is weak, it may be wise to establish drainage and keep the wound clean until the involucrum has become sufficiently strong to hold the general shape of the bone. As a rule, however, when the sequestrum is sharply marked from its surrounding adjacent bone the involucrum is sufficiently firm to hold the general contour of the bone after removal of the sequestrum. Where there are two bones, as in the leg and forearm, the sequestrum can be removed earlier because the healthy bone acts as a splint. The periosteum is stripped from the dead bone together with adherent cortical cells of bone and folded over after disinfecting the cavity from which the diseased bone was removed. The wound can then be closed with the expectation that the periosteum and its thin layer of cambium bone will reproduce the shaft. E. H. Nichols, of Harvard, has done excellent work along this line and has shown that there are stages in osteomyelitis in which the periosteum will produce bone very much more readily than at other times.

The removal of a sequestrum is merely an extended form of the operation that has already been described. A tourniquet is used and the incision is

sufficiently long to enable the sequestrum to be removed and the cavity from which it has come to be explored thoroughly. The tibia is the bone on which the operation of sequestrotomy is most frequently performed. After applying the tourniquet an incision is made the length of the diseased bone and the periosteum is divided, stripped up, and retracted. The involucrum over the sequestrum is usually thin and soft, but portions of it may be firm. It is removed with rongeur forceps, or with a chisel and mallet so that the sequestrum and every portion of the cavity containing it can be thoroughly explored. If it is practical to do so it is well to remove one wall of the involucrum, saving if possible the crest of the bone if it is the tibia, as this is the strongest portion. If one wall is completely removed the soft tissues can fill in the cavity and this will greatly hasten the process of healing (Fig. 419). A small portion of healthy cortical bone left adherent to the periosteum is sufficient to reproduce the shaft of the bone satisfactorily if a splint is applied and the bone is protected from strain during convalescence.

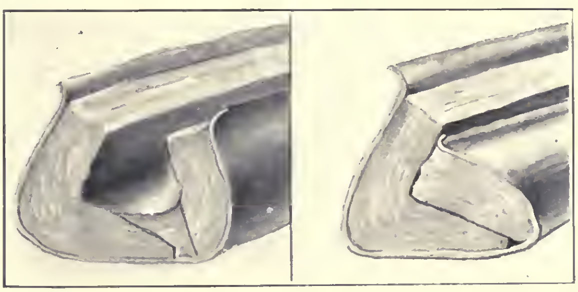

Fig. 420. Fig. 421.

Fig. 420.—Another method of avoiding cavity formation in the bone. One wall of the involucrum has been mobilized.

Fig. 421.—The mobilized wall of the involucrum shown in the preceding figure is so folded as to obliterate the cavity in the bone.

After removing the sequestrum and a portion of the involucrum the cavity is curetted and cleaned with gauze and peroxide. The cavity may then be disinfected with pure carbolic which is followed by alcohol, or tincture of iodine may be applied. If it is quite certain that all the diseased bone has been removed the wound may be closed, filling space that cannot otherwise be obliterated with the Mosetig-Moorhof bone plug. Some surgeons prefer using salt solution and suturing the soft parts to prevent its escape. Sometimes in neglected cases, the involucrum is so dense that it does not seem practicable to remove a sufficient amount to bring in the soft tissues. Here the Mosetig-Moorhof plug may be utilized, or one of several plastic procedures can be done. One wall of the involucrum may be so separated and mobilized that it will fall in on the cavity (Figs. 420 and 421). The overlying soft parts may be undermined and fastened to the depth of the wound by pegs or sutures. This, however, leaves a furrow and a marked deformity, which is objectionable. Grafting of soft parts into the wound by a

pedunculated flap can be done according to the operation of von Eiselsberg. According to this method if the defect is in the lower part of the tibia a flap with its base downward is fashioned over the upper part of the tibia after the lower defect has been prepared by a curet and chisel and the flap which includes the skin, periosteum, and the whole thickness of the cortical bone attached to the periosteum is turned down into the defect (Figs. 422, 423 and 424). Care must be taken not to twist the pedicle too greatly. The

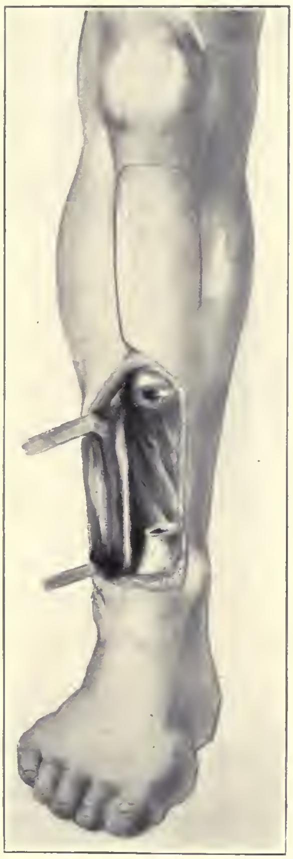

Fig. 422.—Lines of incision for flap to fill defect in the bone. (von Eiselsberg.)

Fig. 423.—The flap has been mobilized and is ready to be turned down in position. (von Eiselsberg.)

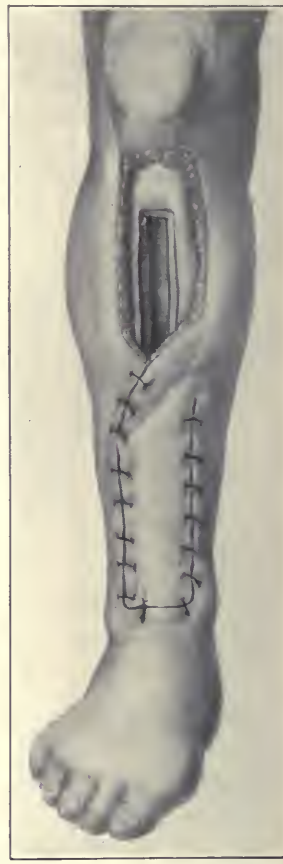

Fig. 424.—The flap is sutured in position. (von Eiselsberg.)

defect in the upper part of the wound is closed as far as possible by undermining and sliding the skin.

Transplantation of fat into a defect of the bone after the cavity has become sterile has been done with some success. Portions of adjacent muscle may also be utilized as a filling if there is but little tendency to reproduce bone. It is best to graft bone only after the cavity has become clean, following the technic of bone grafting that has already been described.

ELEPHANTIASIS

Obstruction of the main lymphatic trunks from the leg causes swelling of the lower extremity which may assume enormous proportions. This swelling is not the result of interference with the blood circulation, but is due solely to obstruction in the lymph current. These cases of elephantiasis are often satisfactorily treated by the operation of Kondoleon, of Greece, who endeavors to secure an anastomosis between the superficial and the deep

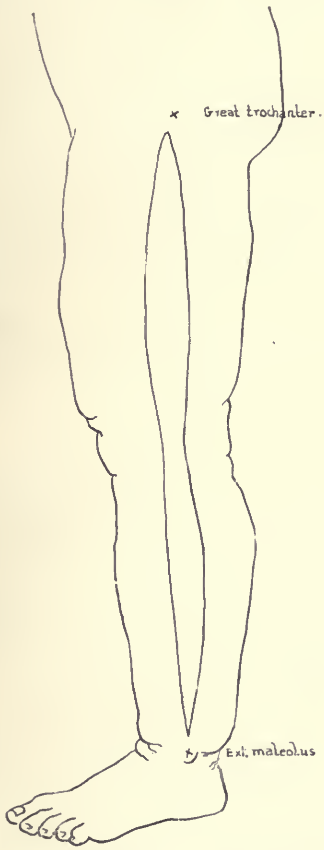

Fig. 425.—Lines of incision for operation of Kondoleon on outer surface of the lower extremity.

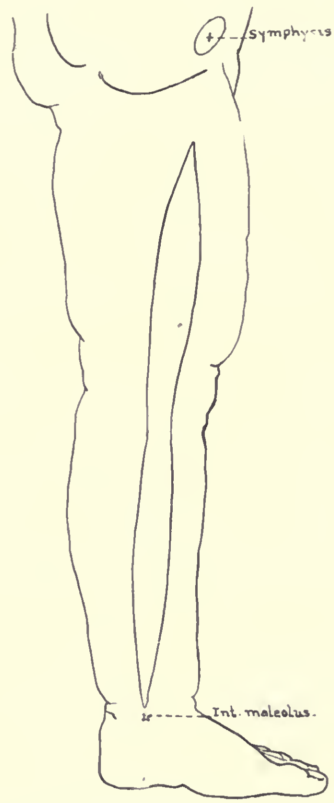

Fig. 426.—Lines of incision for operation of Kondoleon on inner surface of the lower extremity.

lymphatic systems of the leg, as the obstruction that produces the swelling seems to be chiefly if not entirely in the lymphatics that drain the skin and deep fascia of the leg and thigh. This operation has been used with considerable success by Matas, Royster, Hill and Sistrunk. Sistrunk has modified the operation by making it somewhat more extensive and removing a considerable amount of tissue.

Long incisions are made on the outer and, if necessary, on the inner surface of the leg and thigh, extending externally from just below the trochanter

major to just above the external malleolus (Figs. 425 and 426). A large slice of the edematous fat is removed and the fascia is opened down to the muscle. A strip of fascia about two inches wide is excised and the edges of the fascia are fastened to the muscle by interrupted sutures of catgut in order to fix the fascia in position. The edges may be tucked in at the point of suture and in this way will probably prevent the rapid reunion of the fascia. The skin is closed with a continuous suture of tanned or chromic catgut or with silk. The skin and fat should come together over the exposed muscle. If the incision in the outer portion of the leg and thigh does not relieve, an incision on the inner side can be made a month or two later. Here the incision is made from a point near the perineum directly down to just above the internal malleolus. A mass of fat is removed and a strip of fascia lata is excised, the edges of the fascia being fastened to the muscle as after the external incision. The skin being closed with continuous sutures without drainage. By careful hemostasis but little blood is lost and the anastomosis between the deep and the superficial lymphatics is usually so satisfactory as to result in a cure.

The patient should wear a support and promote the lymphatic circulation by hot applications and massage for several weeks after the operation.

VARICOSE VEINS

The type of operation for removal of varicose veins of the leg depends upon the extent and the location of the diseased veins. There are three forms of veins in the lower extremity: (1) those without valves in which the blood may run either way, (2) veins in which the valves direct the blood toward the surface, and (3) veins in which the valves direct the blood toward the deep veins. The perforating branches that connect the deep and superficial veins are most numerous in the middle and lower part of the leg. In the middle of the leg these perforating branches are surrounded by muscles and consequently the superficial veins are frequently the first to dilate at different points, because the bulk of the muscles prevents drainage into the deep veins. The subcutaneous ligation that was formerly practiced is not now considered satisfactory and division or excision of the vein gives better results. The veins may be divided and ligated in the thigh, excising a portion of the main trunk, or a circular incision can be made below the knee and multiple ligations done on the divided veins.

Schede encircles the leg with an incision about the junction of the upper and the middle thirds, cutting all tissues down to the deep fascia, tying both ends of the divided veins, and suturing the skin. Friedel, after ligating the long saphenous in the thigh, makes a spiral incison, beginning below the knee and encircling the leg several times ending the incision on the back of the foot. All veins are tied, but the wound is left open.

Trendelenburg ligates and resects the saphenous vein in three places, in the middle of the thigh, and above and below the internal condyle. Total

resection in the thigh can be accomplished through a long incision from the saphenous opening to the posterior border of the internal condyle and this may be continued to the internal malleolus. The scar at the knee, however, is often an annoyance and if an ulcer is present the incision should not extend to it, so as to avoid infection in the wound.

The operation of C. H. Mayo is simpler and avoids extensive scarring of the skin. He uses multiple short incisions over the course of the vein, be-

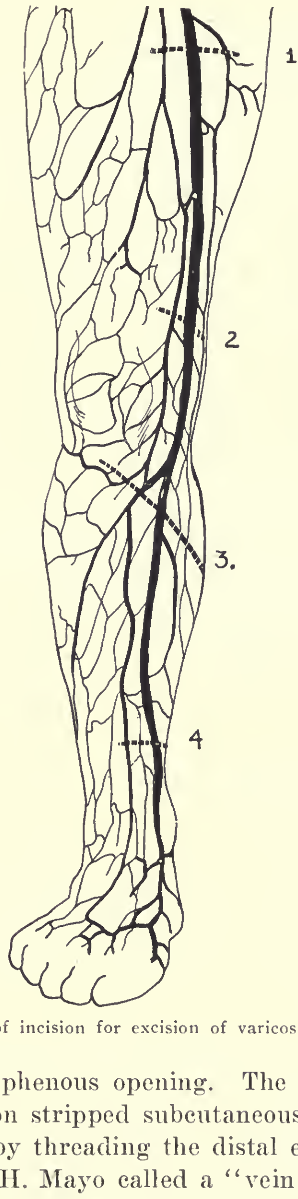

Fig. 427.—Lines of incision for excision of varicose veins of the leg.

ginning just below the saphenous opening. The vein is doubly ligated, divided and its distal portion stripped subcutaneously as far as possible (Fig. 427). This may be done by threading the distal end of the vein through an instrument devised by C. H. Mayo called a "vein stripper." Instead of the vein stripper a medium-sized blunt uterine curet can be used satisfactorily.

When the stripping has been carried as far down the thigh as possible the end of the vein stripper is cut down upon and the vein is brought up into a short incision and loosened from the tissues in its neighborhood. The vein stripper through which the vein is still threaded is again pushed down beneath the skin to a point below the knee if possible, and is again cut down upon (Fig. 428). This avoids making an incision on a level with the knee joint. The vein is brought up through this last incision and ligated below. It is not

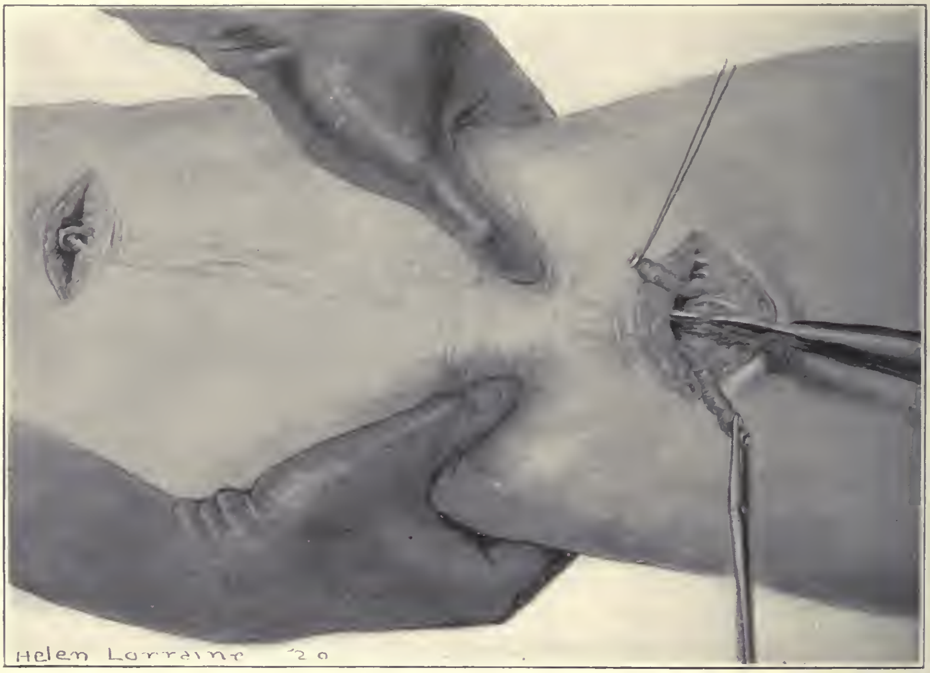

Fig. 428.—Mobilizing a varicose vein and stripping it from one incision to the other by method of C. H. Mayo.

possible to use the vein stripper much below the knee because the varicose veins here are very large and the branches are numerous. Along the inner side of the leg an incision is made either straight or curved and fashioned to give the maximum exposure of the veins, and the veins are excised. If an ulcer is present it should be protected by gauze during the progress of the operation on the veins and after this has been completed, the ulcer may be excised and the raw surface skin grafted with Thiersch grafts.

THE SCIATIC NERVE AND BRANCHES

The technic of operations upon nerves has already been described, but on account of wounds or tumors it may be necessary to expose the sciatic nerve or its two main branches, the tibial and the common peroneal. In exposing the sciatic nerve for stretching or other purposes the patient lies

prone. The tuberosity of the ischium and the great trochanter are identified and an incision is made midway between these points and, beginning just above the gluteal fold, it goes down the leg for about four or five inches. The small sciatic nerve is then seen. The lower edge of the gluteus maximus will be found about the middle of the incision. The hamstring muscles are demonstrated by bending the knee so as to identify them and are retracted inward. The nerve is a little nearer to the tuberosity of the ischium than to the great trochanter. In exposing the upper portion of the sciatic for suturing, the incision is more extensive. The lower part of the incision is vertical as is made for stretching the nerve, but at the gluteal fold it curves sharply outward along the outer border of the gluteus maximus and is carried to the level of the tip of the trochanter major, or higher if necessary. A flap is reflected and turned inward, exposing the upper portion of the sciatic nerve. This incision tends somewhat to prevent infection and gives a satisfactory scar. The internal popliteal or tibial nerve, as it is now called, is exposed by an incision that begins opposite the center of the popliteal space and is carried three and one-half inches downward between the two heads of the gastrocnemius muscle. The short saphenous vein and the small nerve are retracted and after dividing the deep fascia the two heads of the gastrocnemius are separated. The short saphenous vein empties into the popliteal vein beneath the nerve, the tibial nerve being most superficial, the vein next and the artery nearest the joint. The external popliteal or common peroneal nerve follows the outer side of the popliteal space and lies close to the biceps. The nerve passes over the outer head of the gastrocnemius muscle, lying between it and the biceps, and crosses the fibula just below its head beneath the upper fibers of the peroneus longus muscle. When the knee is flexed the nerve may be easily felt just behind the biceps tendon. The incision to expose the nerve is about two inches long and runs along the posterior border of the tendon of the biceps from behind the prominence of the external condyle of the femur toward the posterior border of the head of the fibula. The biceps tendon is exposed and the knee is flexed to relax the tendon. The nerve lies near the attachment of the biceps tendon to the head of the fibula, between this point and the outer edge of the gastrocnemius muscle. Care must be taken to identify the biceps tendon as sometimes a band of fascia may simulate this tendon.

CHAPTER XX

OPERATIONS ON THE THORAX EXCEPT THE MAMMARY GLAND

THE RIBS

Operations upon the ribs are done in two types of cases: (1) those in which there is a disease of the rib itself and the operation is designed to remove the disease by removing the rib, and (2) those in which a healthy rib is removed to gain access to the contents of the thorax, to mobilize the chest wall to fill a cavity, as after chronic empyema, or in cardiolysis when the rigid ribs hold the adherent heart and it is necessary to mobilize the chest wall over the heart.

Operations for tumors involving the chest wall or ribs cannot, of course, be typical, but whenever the pleura is opened certain definite procedures must be followed. The most important of these is to avoid sudden collapse of the lungs. This accident is serious if there is a wide opening in the chest and the mediastinum is not rendered immobile. The late John B. Murphy called attention to this danger and the necessity for fixing a collapsed lung by grasping it with forceps in order that the diaphragm may act satisfactorily.

The chest may be considered as two barrels of a syringe, the midline representing a flexible partition between the two barrels. If the diaphragm is likened to the piston of a syringe it can easily be seen that but little change in pressure can be induced in either barrel by the ascent or descent of the piston if there is a large opening in one of the cylinders of the syringe and at the same time the partition between the two cylinders is so flexible that it readily flaps to either side. If, however, the partition is held rigid, suction can be made in the unopened compartment by descent of the piston, or compression by ascent.

So the action of the diaphragm is embarrassed by a large opening in one pleura. If both pleural cavities communicate with each other, which is uncommon in man, but common in some of the lower animals, the prognosis is much more serious. If the opening into the pleura is small and can be closed by a pad the embarrassment of respiration is greatly relieved, if not done away with, because the pleural cavity being filled with air and the opening into the pleura closed, the median partition is stabilized and respiration goes on satisfactorily. A hole, however, through which the air rushes in and out produces a flapping back and forth of the median partition between the pleural cavities and almost nullifies the function of the diaphragm. In injuries of the pleura, then, the opening must either be closed as soon as possible, or else the collapsed lung must be caught with

rubber-covered clamps or gauze and held firmly during some necessary manipulation so that the median partition is stabilized and the lung of the unopened pleura can expand and contract during respiration.

In operations for removal of sections of the chest wall including the ribs, a differential pressure cabinet was formerly employed in which the patient's head and neck were placed in a cabinet with increased atmospheric pressure, and so the danger of collapse of the lung was avoided. These cabinets were expensive, complicated, and unsatisfactory and the simpler method of Metzer and Auer who introduced intratracheal anesthesia is much more satisfactory. Modifications have been numerous. Samuel Robinson devised an apparatus in which ether may be administered by insufflation through a mask. In intratracheal insufflation anesthesia the electric motor which is used to pump in the air should always be supplemented by a hand or foot bellows to be used in an emergency if the motor breaks down. This bellows as well as the whole apparatus should be thoroughly tested before giving the anesthesia. The pump should be connected with an air filter and a manometer, as well as with a safety valve of ample size, which releases at a pressure of about 25 mm. of mercury. In the early stages of development of intratracheal anesthesia the lung tissue was occasionally ruptured because of the absence of a safety valve. The intratracheal tubes are preferably of woven silk rather than rubber, though a rubber tube of the same consistency as that used in a soft rubber catheter is satisfactory. The sizes vary from 22 to 24 French according to the size of the larynx and the tubes should be marked at two points, one about 12 c.c. from the tip, which indicates the distance of the glottis from the teeth, and the other at 26 c.c. from the tip, which indicates the distance from the bifurcation of the trachea to the teeth. The tube should be of such a size as to fill about half the lumen of the trachea so air can readily escape around it. If too small the returning air escapes too quickly, while if too large excessive pressure is made in the lung and the interchange of air is interfered with. After sterilization the tube is chilled with ice before introduction. It is best introduced by the direct laryngoscope, according to the technic of Jackson, the patient having been previously etherized in the ordinary manner. The tube is inserted after the patient is under full surgical anesthesia. After the tube has been inserted and protected from the teeth by a wedge or a clamp of some device and after the pumping apparatus has been connected, the epigastrium should be carefully noticed to see if there is any swelling of the stomach as the tube may have been inserted into the esophagus instead of into the trachea. This mistake has happened, particularly if the tube is inserted by the sense of touch, as is the practice with some operators, instead of through the direct laryngoscope of Jackson.

One of the chief disadvantages of intratracheal anesthesia or any form of differential pressure is the obstruction to the circulation in the lung. In normal respiration the obstruction to the circulation of the blood in the lung capillaries is greater after deep than after shallow inspirations, so that with

the continuous expansion of the lung by any form of intratracheal insufflation or differential pressure the circulation of the lung becomes greatly impaired and this may account for some of the deaths that have occurred after long operations upon the lungs under differential pressure. It is best to permit the lungs to collapse about once every minute or even oftener, except at some critical stage of the operation when it is necessary to have a continuous expansion for a longer time. Just before closing the wound and after the last stitch has been inserted but before it is tied, a forceps is introduced into the pleural cavity and opened so as to spread the wound slightly, while the pressure within the lung is raised sufficiently to cause it to fill out the pleural cavity. Air left after surgical operations seems to predispose to infection, and drainage in these cases is always undesirable.

If, however, the pleura is accidently opened while operating upon the ribs either plugging the opening quickly so as to stabilize the air that has already entered, or, if the wound is a large one, grasping the collapsed lung firmly with gauze or a soft forceps and holding it steady will usually serve to tide over the crisis.

In removing sections of the chest wall for tumors the same general precautions should be exercised as in operating for malignant diseases elsewhere. An effort should be made to remove the tumor in one mass. The general anatomy of the chest wall must be borne in mind. A knowledge of the location of the intercostal and the internal mammary arteries is important. As little blood must be lost as possible and this can best be accomplished by clamping the vessels as they are divided and by separating the intercostal vessels from the lower border of the rib and doubly ligating them before they are divided. Provision must be made for closure of the pleural cavity after removal of the tumor, if the defect is so large as to prevent approximation of the pleura. A large flap with an ample base and containing as much subcutaneous tissue as possible is turned into the defect. The flap should be outlined, dissected up, and be ready to be placed over the defect, being protected by moist gauze, before the tumor is excised. In this way embarrassment from the exposure of the open pleura will be as short as possible. If an intratracheal apparatus is unavailable, or if anything goes wrong with it, the opening should be quickly filled with quantities of gauze wrung out of salt solution, the tumor rapidly removed, and the flap which has previously been formed is sutured in position, except at its lower margin, before removing the gauze. Interrupted sutures are inserted into the lower portion of the wound between the flap and the chest wall but not tied. The gauze is then quickly removed and the sutures are tied. The sutures of the flap of the chest should be interrupted silkworm-gut and should be placed close together, but tied not too tightly. The edges of the wound may be covered with strips of iodoform gauze that have been soaked in compound tincture of benzoin. An abundant dressing is applied over the whole wound.

Aside from tumors such as carcinomas which will demand the excision not only of the rib but its periosteum and surrounding tissue, there are two

indications for operation in which the periosteum should be removed along with the rib or its cartilage. Occasionally in a rigid chest wall where the chest is barrel shaped and the ribs are fixed, particularly in certain types of asthma, it may become necessary to mobilize the ribs by excising parts of the costal cartilage. This is done by removing about one and one-half inches of the costal cartilage of the second, third, fourth and fifth ribs. In some cases operation on one side alone may be all that is necessary, but usually a bilateral operation is more effective. It will probably be safer to operate upon the two sides at different times. These cartilages may be removed through a single long vertical incision which exposes all of the cartilage, or by multiple incisions over each cartilage. Sometimes a portion of the bony rib is included along with the cartilage. It is doubtless better to use a single incision which begins just below the clavicle and goes downward about three-fourths of an inch from the sternum. Care should be taken not to wound the internal mammary artery. Each cartilage is cut close to the sternum and lifted upward along with its perichondrium and dissected outward toward the rib. After the cartilages have been removed, the intercostal structures are sewed together to obliterate the dead space and lessen the chances of regeneration of the cartilage. The operation can be done under local anesthesia as patients in which the operation is indicated are not good subjects for a general anesthesia. Similarly in certain rib resections to obliterate cavities in the pleura or when the breast or pericardium are adherent to the chest wall, the periosteum should be removed along with the rib. This latter operation is known as cardiolysis. It is only applicable to that type of pericarditis which is characterized by adhesions between the pericardium, pleura, diaphragm and mediastinum, practically gluing together these structures and the heart. Separation of these adhesions alone does but little good and is commonly followed by early recurrence. In instances in which this operation is indicated the work of the heart is seriously interfered with and the systolic contraction is followed by a marked bulging during diastole.

For cardiolysis an incision is made which is curved with its convexity downward on about the level of the fourth rib and is carried from the left border of the sternum to the anterior axillary line. The incision is carried to the ribs and the skin and muscle on each side of the wound are dissected up, exposing the third, fourth and fifth ribs from the junction with their cartilages for a distance of about four inches. These three ribs are resected, preferably with their periosteum as otherwise they are likely to regenerate. This, however, must be carefully done over the outer portion of the wound as there is great risk of injuring the pleura at this point. It may probably be wiser to remove the periosteum with the rib over the inner inch and a half where the adhesions are so dense as to obliterate the pleura and in the outer portion of the wound where the pleura is thin and likely to be injured the ribs can be removed subperiosteally. After four inches of the third, fourth and fifth ribs have been removed, the inner inch and a half being removed with the periosteum, the muscle is brought together after hemostasis has been com-

pleted. The skin is closed in the usual manner. Sometimes the costal cartilages are also removed with the ribs.

Typhoid ribs occur after typhoid fever and as the incidence of typhoid fever has been greatly lessened by preventive medicine and vaccination, this disease is now rare. W. W. Keen brought this affection into prominence in his monograph on surgical diseases of typhoid fever, in which he reports several cases. Operation for this condition presents certain features that are different from operations for pure pyogenic infections. The disease often develops months and even years after an attack of typhoid and sometimes, unless a careful history is taken or serum tests are made, the occurrence of typhoid fever may be overlooked. Typhoid bacilli may remain in the ribs in pure culture for months or years after the attack of typhoid. The disease seems particularly likely to occur about the junction of the rib and its costal cartilage, and infection of the costal cartilage is obstinate.

A thorough exposure of the diseased rib or ribs is made by an incision parallel to the ribs and the tissue on either side is undermined and retracted. If a fistula exists the incision is so made as to surround the fistula and every care is taken to prevent infection of the soft tissues. By previously disinfecting the superficial part of the fistula and packing it with a strip of gauze soaked in tincture of iodine just before the operation contamination of the adjacent flaps may sometimes be prevented. After the flaps of skin and subcutaneous tissue with the muscle over the ribs have been freely mobilized and retracted the periosteum over the rib and the perichondrium over the cartilage are incised and stripped up with a periosteal elevator. Great care must be taken in doing this on the under surface of the rib because the pleura is here very easily injured. In resecting a rib for empyema where the pleura is thick and where the purpose of the operation is to incise the pleura there is but little need for care, but with a typhoid rib and normal pleura the opening of the pleural cavity with the possibility of infecting the pleura should be carefully avoided. By hugging the posterior surface of the rib and exposing its edges and the costal cartilage thoroughly before attempting to strip the posterior layer, and then working chiefly from above downward, injury to the pleura can usually be avoided. It is best fully to separate the rib and divide it with bone forceps at the outer portion of the wound. It can then be gently lifted and the periosteum along with the pleura stripped off from without inward as the end of the rib is elevated. When the junction with the cartilage is reached it may be necessary to cut across the cartilage and remove the rest of the diseased cartilage with a sharp curet. Usually the lower ribs are affected and their costal cartilages are fused together near the sternum. Not only the rib but the costal cartilage must be removed well beyond the visibly affected area, else a recurrence is certain. As soon as the rib has been resected its bed and the stump of the rib should be protected by moist gauze to avoid infection of the exposed end of the rib. It is wise to stitch the periosteum over the stump of the rib before proceeding further with the operation. Af-

ter removing a sufficient amount of the cartilage well into the healthy tissue the exposed surfaces of the cartilage together with the periosteum or perichondrium that has been left are swabbed with gauze soaked in tincture of iodine. The wound is closed with interrupted sutures of silkworm-gut but provision should be made for drainage by a stab wound at a dependent portion of the wound through which a rubber tube is inserted. The dressing should be firm so as to fix the ribs and limit respiration, otherwise there will be considerable pain from the motion of the unattached rib. Usually there is a congestion of the pleura because of the proximity of the operation and symptoms of localized pleurisy may appear merely from the trauma that has been done over the pleura and not from any infection. Often the ribs and cartilage are at least partially reproduced from the periosteum and perichondrium together with some of the cambium layer which has been left after removal of the rib.

EMPYEMA

Removal of the ribs to gain access to the contents of the thorax is a much simpler procedure than the operation for typhoid ribs. When resection of a rib is indicated for empyema the sixth or seventh rib in the midaxillary line or the ninth rib just external to the angle of the scapula is best for an unconfined empyema. The operation should, as a rule, be done under local anesthetic and with care it can be almost painless. Before beginning the operation it is definitely ascertained that pus is present by aspirating the pleural cavity just above or just below the portion of rib that the surgeon intends to remove. After infiltrating the skin and subcutaneous tissues with novocain solution an incision is made down to the periosteum. Bleeding points are clamped and tied or whipped over with catgut in a needle before proceeding with the operation. After the pleural cavity has been opened and pus has contaminated the wound any manipulation, such as tying vessels or securing bleeding points, is unwise as the infection may thereby be spread. The periosteum is infiltrated with novocain and incised about the middle of the rib for a space of two and a half inches. Tissues along the lower and upper border of the rib should be particularly well infiltrated. The periosteum is stripped up, hugging the rib closely, especially at its lower border where the main intercostal vessels lie. After exposing the bone above and below, the posterior part of the periosteum is infiltrated with a small, fine needle and the periosteum is further separated from the rib. This can be readily done by inserting the edge of a periosteal elevator and making lateral motions. The periosteal elevator is then placed beneath the rib which is divided with bone forceps at the outer angle of the wound. The inner portion is raised, the periosteum stripped further back if necessary, and about two inches of the rib are removed. The periosteum is incised longitudinally in the middle and pus allowed to escape. It should not flow too freely because this may produce such sudden changes in the lung and in

the circulation of the lung that the patient may collapse. No effort should be made to irrigate the cavity though any large pieces of fibrin that are loose and protrude from the wound should be removed. A large rubber tube about three-fourths of an inch in diameter and having two or three perforations is inserted into the wound for four or five inches. The outer portion of the tube is split in two pieces and each half is perforated and a long tape tied into the perforations. The tapes are carried around the body and tied to each other. No effort is made to evacuate all of the pus immediately, though most of it may be allowed to escape, stopping the flow at intervals if coughing or other symptoms show that the patient is being too much embarrassed by the rapid flow of pus. Abundant dry sterile dressings are applied and renewed every few hours until the discharge decreases. The clean dressing should be ready and should be applied promptly after

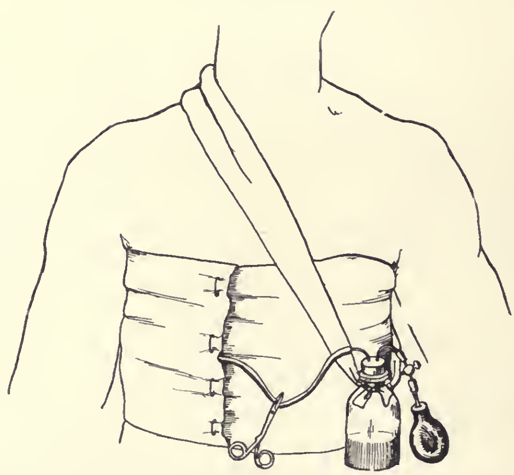

Fig. 429.—A method of drainage of empyema by negative pressure.

removing the soiled dressing so as to protect the pleural cavity from the free and unobstructed ingress of air.

Resection of a rib is not always necessary in the treatment of empyema. The indications for the proper type of operation must first be ascertained. In patients who are desperately ill and, particularly, those with streptococcic infection that follows certain types of pneumonia after influenza, resection of the rib is distinctly contraindicated. Here the patient's resistance is at the lowest ebb, the leukocyte count is low, and no more should be done than is absolutely necessary. The ends of the rib, too, are particularly liable to become infected in such cases and will constitute a source of sepsis. Aspiration or puncture with a trocar and cannula in an intercostal space with the insertion of a tube through the cannula after the trocar has been removed, can be quickly done with but little shock to the patient and in this type of cases is undoubtedly preferable to resection of the rib.

When the resistance is low, particularly in the early streptococcic infec-

tions, operation should be along as conservative lines as possible and always under local anesthesia. The diagnosis is definitely determined by aspiration and a short incision is made through the skin in the intercostal space through which the drainage would be most satisfactory and usually in the midaxillary line. The incision is made close to the upper border of the rib to avoid the intercostal vessels and is only about half an inch long. A trocar and cannula are selected so that a No. 17 French catheter can be threaded through the cannula. The trocar and cannula are thrust through the incision into the empyema. The trocar is withdrawn and a soft rubber catheter with two extra openings near its end is threaded through the cannula until about three or four inches of the catheter remain in the empyema cavity. The cannula is gradually withdrawn while threading more and more of the catheter into the pleural cavity. The amount of the catheter that remains in the pleural cavity can be readily determined by measuring the portion on the outside of the incision with another catheter. The tube is so adjusted that about six inches remain within the pleura. The catheter is fastened to the

Fig. 430.—A rubber tube for drainage of empyema. The wide flange permits the formation of a valve with a sheet of rubber dam.

skin with adhesive straps and connected with a rubber tube that carries the drainage into a bottle. Three or four days later negative pressure can be arranged by connecting the drainage tube with a bottle from which the air has been pumped, or with a collapsible rubber bag, such as the Politzer bag (Fig. 429). Irrigation of an empyema cavity, certainly in the early stages, is never advisable.

There are many methods of producing negative pressure in the pleural cavity, or at least of preventing the free entrance of air. The patients may often be permitted to walk around with the drainage tube attached to a bottle that is kept at a partial vacuum. While the patient is in bed the entrance of air into the pleura may be effected by connecting the drainage tube with a tube of rubber dam. This is long, easily collapsible, and terminates in a bottle containing some antiseptic solution. On expiration or coughing the fluid from the pleural cavity is forced through this tube of rubber dam, but on inspiration the tube collapses and prevents ingress of air. This method, which has been suggested by Joseph Ransohoff, of Cincinnati, is simple and may be all that is required. A valve can be arranged over the exit of the tube if there is a shoulder to the tube. A rubber tube that resembles a

spool, having a wide outer flange and a narrow or no inner flange is used (Fig. 430). After insertion of this tube a little curtain of rubber dam is fastened over the upper margin of the tube, and will act as a valve, permitting the outflow of drainage without the entrance of air. This valve, however, is likely to become displaced though such a tube has distinct advantages in enabling the drainage through the thoracic wall around the tube to be air

Fig. 431.—Operation of Estlander for chronic empyema. A flap has been turned up, the ribs are resected and the cavity of the empyema is exposed.

tight. The valve construction can be omitted and the opening of the flanged tube connected with another rubber tube and negative pressure can be provided for by some of the methods that have been described.

Any tube used for the drainage of empyema in the intercostal space should be either very stout elastic tube or a rigid rubber or metal tube, for the ribs may compress and occlude it.

In an old empyema where for some reason drainage has been inefficient and

the lung has collapsed, a space is left which is difficult of closure. Two principles are followed in operation for the cure of this condition. In one the ribs themselves are removed in order to mobilize the chest wall and permit it to sink into the cavity. In the other an attempt is made to promote expansion of the lung by removing from it the membrane which binds it down.

In mobilizing the chest wall two types of operations have been employed. In one operation, which is called the method of Estlander, sections of several

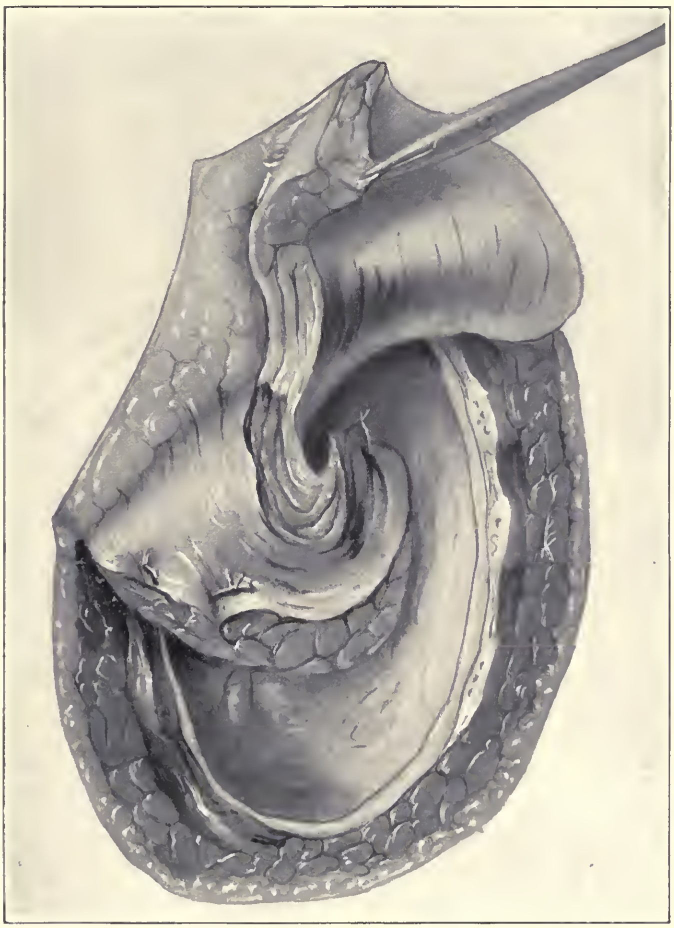

Fig. 432.—The muscle flap is dissected and is sutured into the wound.

ribs are removed over the cavity. The upper portion of the pleural cavity is more difficult to close than the lower portion, as in the lower portion the diaphragm frequently ascends to help the obliteration. Care must be taken, then, to remove the ribs as high as possible. This may be done by a U-shaped incision or by straight incisions so fashioned that two ribs can be removed from each incision, which is made in the intercostal space, the soft tissues being retracted above or below. The ribs removed are usually the second, third,

fourth and fifth, though more can be resected if necessary. The disadvantage of this operation is that often in these old cases the pleura and chest wall are so thickened by the inflammation that the chest wall will not collapse even after the ribs have been removed.

Here the operation of Schede may be done. An incision begins at the origin of the major pectoral muscle on a level with the axilla and is carried downward to a point at the bottom of the pleural sac, which is usually the tenth rib in the posterior axillary line. The incision curves along the lower part of the chest, coming up behind the scapula at a point about the level of the second rib between the spine and the scapula. The flap includes all the tissues down to the ribs and to the intercostal muscles and is dissected up freely. The ribs that are exposed are subperiosteally

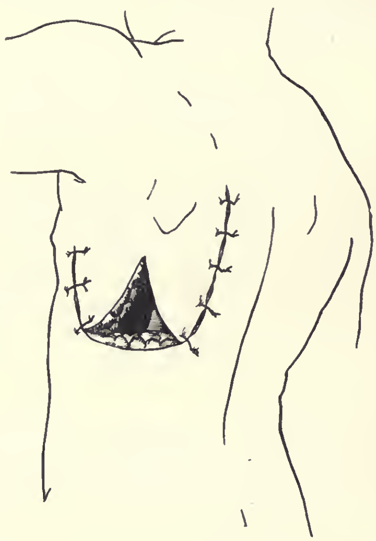

Fig. 433.—The skin flap is sutured in position. It is not usually sufficient to cover the whole cavity.

resected from their tubercles to the costal cartilage, dividing the rib about its middle with bone forceps and dissecting it from this point outward and forward until a sufficient amount of rib is removed. A long incision is made through the periosteum of one of the removed ribs and the pleural cavity is explored so the extent to which other ribs or tissue should be removed is accurately ascertained. After a sufficient amount of the ribs has been resected, all of the tissue is removed that seems to be necessary to expose the cavity thoroughly, including the periosteum, intercostal muscles and the thickened pleura (Fig. 431). The intercostal vessels are secured if possible before division by clamping and are ligated after the tissues have been removed. Every bleeding vessel is clamped. Granulations are wiped away with dry gauze and the flap which was originally reflected is turned down over the outer surface of the collapsed lung and fastened in position with sutures and pads. (Fig. 432). The flap is not sufficient to cover the whole of the wound but it is tucked in to cover the lung

surface of the old empyema cavity (Fig. 433). It is important not to use strong antiseptics in such an operation as the great extent of raw surface will make absorption of some antiseptics so great as to be toxic.

Such an operation is exceedingly dangerous on the class of patients in whom it is indicated and it is frequently best done in two stages, first removing the flap and excising one or more of the ribs, and later removing the chest wall including the rest of the ribs, intercostal muscles, periosteum, and parietal pleura.

Frequently the form of flap, as suggested by Schede, is modified or entirely changed. S. Robinson has suggested a T-shaped flap with the horizontal portion under the axilla as this gives greater nutrition to the flaps. It would be difficult to close the opening by this flap if the deepest part of the cavity is at the upper portion of the pleura. Occasionally muscle, fat or in women the mammary gland has been transplanted by a flap to fill in the cavity of an obstinate empyema.

According to the technic of Robinson the muscles over the chest may be dissected free from the skin and implanted as a flap into the empyema cavity. Carl Beck utilizes skin flaps which are held in position by tampon, no stitches being used. The denuded surface is inclined to heal rapidly.

The operation of Fowler embodies the principle of removing the membrane that binds down the collapsed lung. Fowler and others noticed that in most cases of chronic empyema, even though the lung has been collapsed and bound down for years, it has very considerable resiliency if the membrane that covers it is removed. The pleural cavity is freely exposed by the resection of three or four ribs through an incision, which is made to include the orifice of the sinus. Four inches of the fifth and sixth ribs are removed and the parietal pleura is widely opened. Blunt dissection is begun, first in the direction of the diaphragm, and the fibrinous membrane is peeled off from the lung upward and toward the midline. It is finally detached from the lung above. If the empyema has been drained for more than five months the lung is not likely to expand sufficiently to fill the cavity. Ransohoff in some cases where the peeling off of the membrane is difficult made multiple incisions over the collapsed lung which are carried down through this membrane and criss-crossed in such a manner as to permit the lung to expand without the necessity of dissecting off the entire membrane. It is usually best to combine the principle of Estlander in multiple resection of the ribs with that of decortication of the lung. Of course, where the existence of the empyema has been so long that the lung has been hopelessly collapsed and expansion is impossible decortication will be useless.

THE LUNG

Surgery of the lung necessitates approach to the lung through the pleura. Where the lesion is small this may be done by the same method of resecting the rib that has been described in empyema. If, however, the opera-

tion is to be extensive or a considerable section of the lung is to be removed, the exposure should be ample and is probably best effected by an intercostal incision through practically the whole length of the seventh intercostal space with forcible separation of the ribs by "rib spreaders," which are controlled by powerful levers or screws. Or exposure may be aided by resection of a few inches of the fifth, sixth and seventh ribs posteriorly near their tubercles. This makes the mobilization of the chest wall less difficult.

Abscess of the lung may demand operation. The abscess should be accurately located by physical signs, x-ray and an aspirating needle. A. D. Bevan[1] practices incision in an intercostal space down to the pleura under local anesthesia. This incision is about three inches long and is carried down carefully through the intercostal muscles which are gently divided to explore the pleura (Fig. 434). If the pleura is normal in appearance the lung can be seen moving through it. The parietal pleura is pressed inward and the ab-

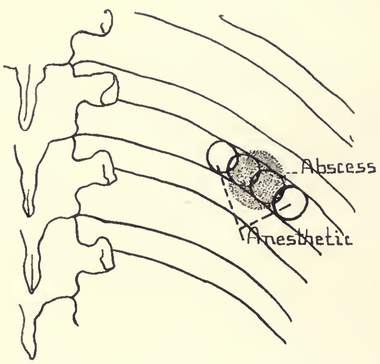

Fig. 434.—Diagram showing method of injecting local anesthetic for operation on abscess of the lung. The abscess is represented by the shaded area. (Method of A. D. Bevan.)

scess is aspirated for diagnostic purposes. The needle should be a very fine one so its withdrawal will not permit leakage into the pleural cavity. The wound is then packed with iodoform gauze which holds the parietal pleura against the pleura of the lung over a spaee about two inches in diameter (Fig. 435). In this manner adhesions are produeed between the parietal and the visceral pleura without opening the pleural eavity. Four or five days later the packing is removed and the lung abseess is again aspirated. With a sharp-pointed eleetric cautery a tunnel is eauterized through the lung tissue to the abscess cavity alongside the aspirating needle which is carefully kept in position (Fig. 436). As soon as the eavity is entered a rubber drainage tube, which is not easily compressed, sueh as a soft rubber catheter, is inserted into the abscess eavity and fastened in position by suturing it to the edge of the skin wound and also by inserting a safety pin.

C. A. Hedblom,[2] of the Mayo Clinie, reports a series of operations for ab-

[1]Surgical Clinics of Chicago, April, 1919, W. B. Saunders Co., Philadelphia, pp. 349-354.
[2]Med. Rec., New York, September 13, 1919.

scess of the lung and advises resection of about three ribs under local anesthesia with a larger exposure of the abscess cavity.

After operation the drainage may persist for months or years and the fistula that is left is difficult to close. Bevan,[3] under local anesthesia, resects the fistulous tract left by prolonged drainage of a lung abscess (Fig. 437).

Fig. 435.—An incision has been made down to the parietal pleura, and the wound is packed with gauze. (Bevan.)

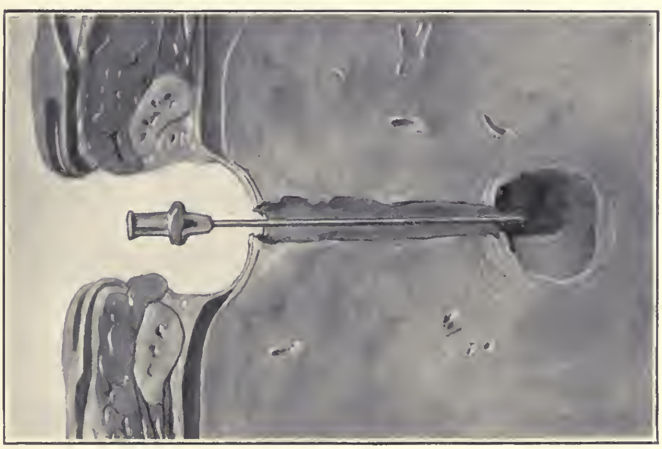

Fig. 436.—Several days later the abscess is opened with an electric cautery which follows the aspirating needle. (Bevan.)

After resecting about three and one-half inches of three or more ribs in order to give ample exposure, the fistulous tract is grasped with forceps and pulled down. The fistulous opening is split up until the abscess cavity is found (Fig. 438). The abscess cavity and the fistula are lined with a tough membrane which Bevan dissects out under local anesthesia, beginning with the lining

[3]Surgical Clinics of Chicago, December, 1919, pp. 1319-1324.

membrane of the abscess and dissecting from that down to the opening of the fistula, using the fistulous tract as a tractor (Fig. 438). A small portion of the adjacent lung tissue is included with the lining membrane of the abscess and the fistula. The bronchus which opens into the abscess is left without a suture (Fig. 439). The cavity is packed with iodoform gauze and no effort is made to close the incision except by a few sutures in the skin at the extremities of the incision.

Wounds of the lung may be sutured, particularly when it is necessary to control bleeding. Often, however, bleeding can be controlled merely by opening the pleural cavity, which permits collapse of the lung and so checks hemorrhage unless a very large vessel is injured.

Fig. 437.—The lines of incision for closure of a fistula following abscess of the lung. (Bevan.)

In injuries of the lower lobe of the lung an intercostal incision in the sixth or seventh interspace, which extends the complete length of the rib, gives excellent exposure when used in connection with a rib spreader. This is also quick exposure and avoids the necessity of resection, which not only takes more time, but involves additional trauma and loss of blood. At the conclusion of the operation the ribs are brought together by stout interrupted silk sutures, which are passed around the ribs and tied. Usually three such sutures at different portions of the wound are sufficient. The upper lobe is best exposed by a curved incision with its convexity downward, beginning in front at the second intercostal interspace, going down below the angle of the scapula, and up again parallel to the spine. In this way the scapula can be swung upward before incising the third interspace. The rib spreader is inserted. The lung is drawn up into the wound after protecting the pleura as well as possible by carefully packing it off with moist gauze. Bleeding points are sought for and sutured, preferably with chromic or tanned catgut.

The mattress type of suture or the ordinary single suture may be used. The sutures should be tied gently, else they will cut out. If intratracheal anesthesia is used the pressure should be increased so that the lung barely fills the pleural cavity just before the last sutures that render the pleura air tight are tied.

In some instances, as in localized tumor or bronchiectasis, excision of a lobe of the lung may be necessary. In excision, the lung is exposed preferably under intratracheal anesthesia with a long intercostal incision and rib

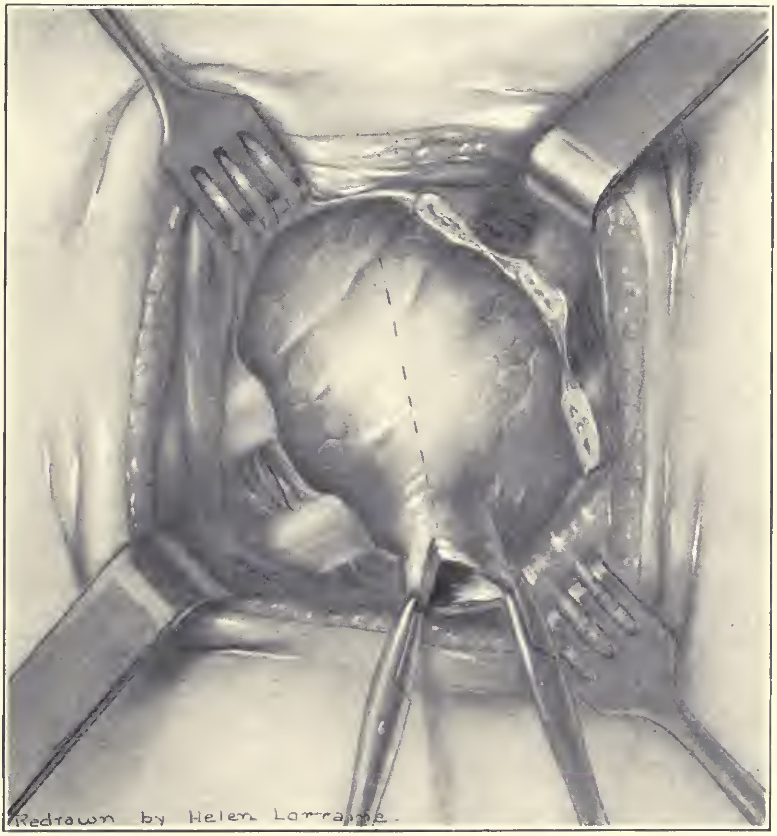

Fig. 438.—The ribs have been resected and the fistulous tract is being dissected. (Bevan.)

spreaders, or resection of one or more ribs may be done. After exposure the diseased lobe is isolated and the pedicle crushed as near the hilum as possible with a strong clamp. The lobe is cut away and the vessels are tied. A stout ligature is placed on the stump. A suture is passed from the stump to the chest in order to prevent retraction of the stump and to stabilize the mediastinum. This suture should not be tight. A large cigarette drain is carried down to the stump of the resected lobe and brought out through the chest wall.

S. Robinson[4] has done a number of successful resections of a lobe of the

[4]Jour. Am. Med. Assn., 1917, lxix, 355-357.

lung and he prefers doing this operation in two or three stages and without any differential pressure apparatus of any kind but simply with the ordinary anesthesia. He does not use intratracheal anesthesia but in bronchiectasis he sometimes inserts a small tube through the larynx into the trachea to remove excessive secretions by suction while he is operating. The incision he prefers is crescentic with its convexity downward. It begins at the fifth rib

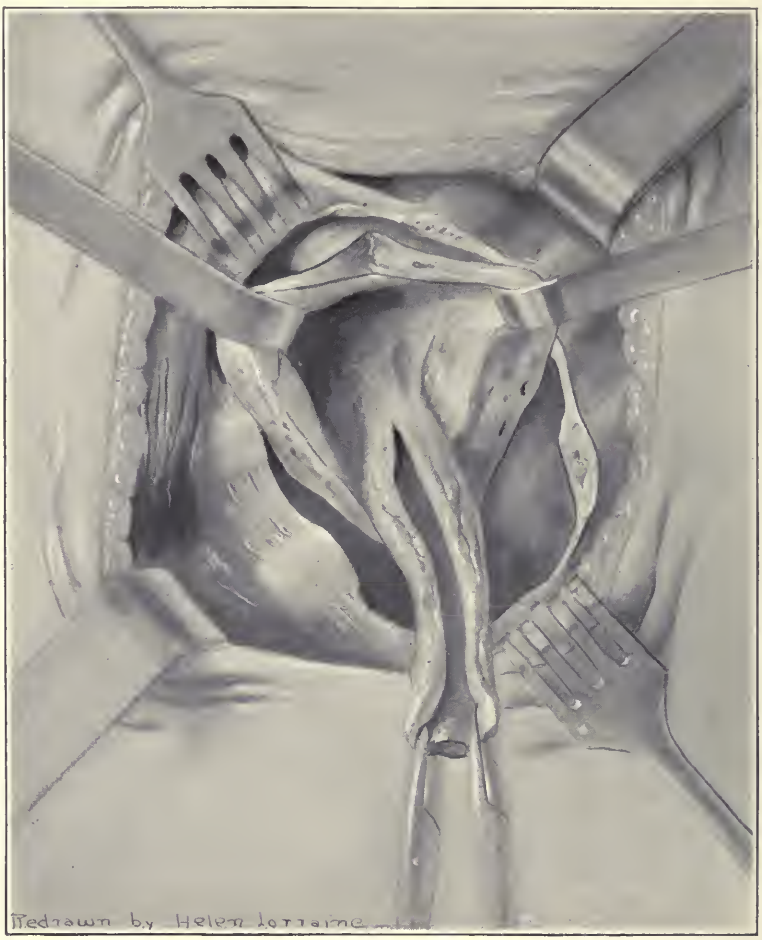

Fig. 439.—The dissection of the fistulous tract has been almost completed. This is facilitated by traction on the walls of the tract. (Bevan.)

two inches from the spinal column, is carried across the eighth rib in the scapular line and then up to the level of the sixth rib in the mammary line (Fig. 440). Skin and fat are dissected from the muscle for about one inch. The muscle fibers are divided transversely between clamps. The seventh, eighth and ninth ribs are resected subperiosteally from their angles to the anterior axillary line. The intercostal bundles are tied and removed. The skin and muscle flap is then replaced and the wound sutured

without drainage. A week later the second stage of the operation is undertaken and the flap is retracted after removing the stitches. New adhesions will have formed with the upper lobe which will anchor it in position. The pleura is opened widely and the adhesions are separated first from the diaphragm so that a clamp may be applied to the hilum of the lobe if necessary (Fig. 441). The upper adhesions are then separated. If separation of adhesions is difficult it is best to make a third stage and remove the lobe of the lung a week later. When this is done a long curved clamp is placed on the root of the lobe to be excised and the lobe is cut away half an inch from the clamp (Fig. 442). The blood vessels and the bronchi are tied separately with tanned or chromic catgut and a mass ligature of kangaroo tendon or braided silk is placed just proximal to the clamp and tied firmly as the clamp is released.

Fig. 440.—The line of incision for excision of a lobe of the lung. (S. Robinson.)

According to Robinson there is always some leakage of the bronchial stump and it is not wise to attempt to close the bronchus by burying it. The wound is packed with gauze, no drainage tube being used, and the gauze is not disturbed for four days when it has become foul and as much of it is removed as possible without too much pain. Repacking is carefully done to prevent pocketing. A drainage tube should not substitute gauze packing at any time. It will probably take about four months for obliteration of the cavity.

The production of artificial pneumothorax may be necessary for the control of hemorrhage, or for the cure of pulmonary tuberculosis. It may be done with a trocar and cannula, or with a hollow needle. In emergency cases puncture of the pleural cavity can be performed with an ordinary aspirating needle, shoving the skin to one side so that when the needle is withdrawn the skin will act as a valve to prevent the entrance of air. In tuber-

culosis, or where there is no emergency, the operation should be performed with more care and nitrogen introduced instead of air. Oxygen is rapidly absorbed but nitrogen is absorbed much more slowly. The gas is warmed by passing it through a rubber coil which lies in a basin of hot water between the tank and needle. A manometer is used and gas is admitted until the patient either gives signs of discomfort or until only a slight pressure is shown. The gas is not introduced until the manometer demonstrates by negative pressure and oscillation that the pleural cavity has been entered. If the patient begins to complain of difficult breathing the injections of gas

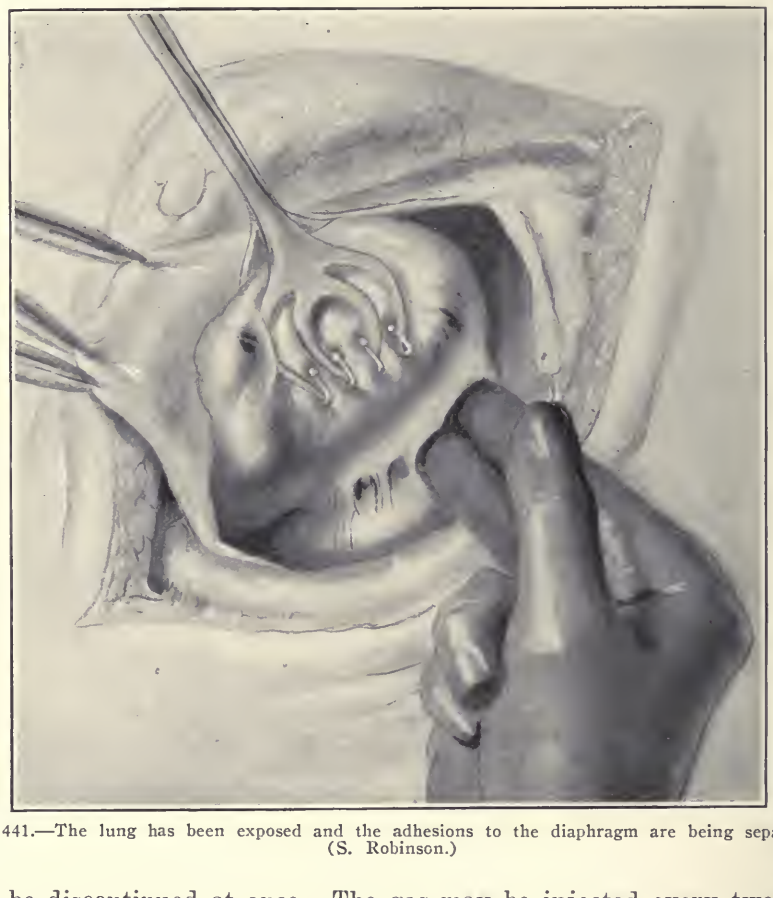

Fig. 441.—The lung has been exposed and the adhesions to the diaphragm are being separated. (S. Robinson.)

should be discontinued at once. The gas may be injected every two to five days until complete collapse of the lung is obtained and a positive pressure of not more than 3 cm. is shown on the manometer. This method is more comfortable and avoids the dangers that would occur if complete collapse of the lung is attempted at one sitting.

In producing an artificial pneumothorax for the cure of tuberculosis several points should be emphasized. The amount of nitrogen introduced at each sitting varies from 200 to 400 c.c. Some patients may stand more than

others. The anterior or posterior axillary line and the ninth intercostal interspace are usually chosen. If on account of adhesions or for other reason this region is not satisfactory the third interspace near the anterior axillary fold is selected. It is best to infiltrate the tissues with novocaine through a fine needle in order to make the procedure as painless as possible, then a larger needle can be used for the introduction of the gas, pulling the skin either up or down before inserting it so that it will have the effect of a valve and cover the puncture of the needle and prevent the escape of the gas. After the needle has penetrated the pleural cavity if it is introduced carefully and the manometer watched the lung will not be injured. After complete collapse of the lung

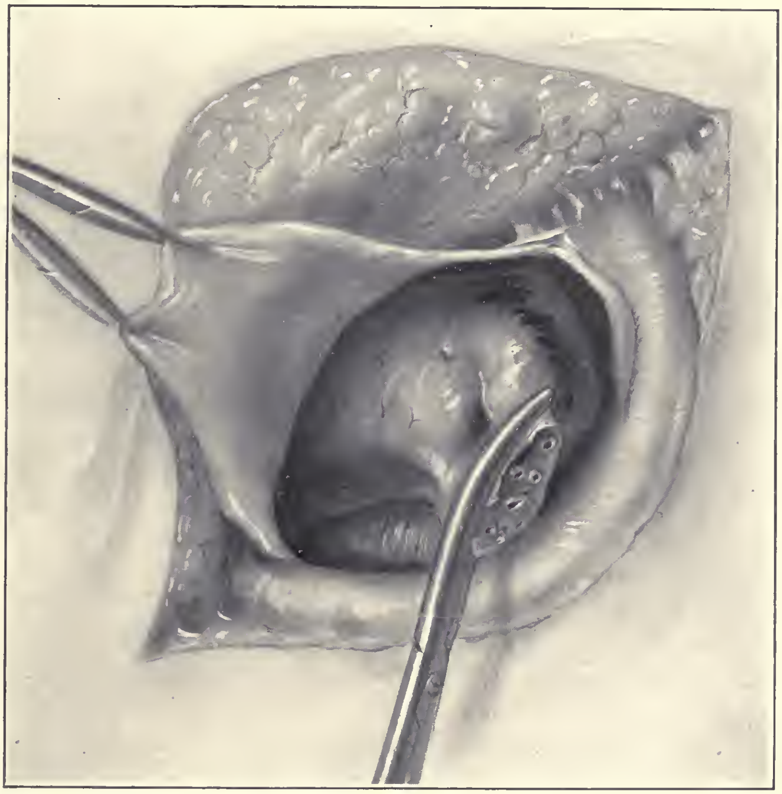

Fig. 442.—The lobe of the lung is excised after clamping the pedicle. (Robinson.)

has been procured over a series of injections given every two days no further treatment need be given for a month or longer. The patient should rest in bed for a day after the injection and if there is any embarrassment of respiration the injection should be either discontinued or at least not repeated. The lung should be kept collapsed from two to three years except in cases with large cavities where the collapse should be maintained indefinitely.

In mediastinal tumors an incision is made from the sternoclavicular articulation downward to about the level of the third rib and then outward in

the fourth intercostal space either to the right or left as may be indicated. The tissues are divided down to the infrahyoid muscles and the sternum, the index finger is introduced into the notch above the sternum and gradually carried down the posterior surface of the sternum, hugging the bone as close as possible. The pleura is exposed in the third interspace after separation of the major pectoral and intercostal muscles and the internal mammary vessels are tied and divided. The index finger of the left hand is inserted through the third interspace and pushed upward close to the sternum until it meets the index finger of the right hand. In this way the vessels of the mediastinum are shoved out of the way and the sternum can be divided longitudinally with forceps. The raw surfaces are covered with gauze and forcibly retracted. The tumor is dealt with and the tissues are replaced in position and held by stout sutures passed around the sternum or through drill holes along its edges. If drill holes are made care is taken to protect the tissues beneath from the drill point as it penetrates the sternum.

THE PERICARDIUM AND HEART

The pericardium occasionally, from trauma or disease, requires aspiration or incision. In pericarditis the effusion may be so marked as to interfere with the action of the heart, and unless the pressure is relieved the patient will die. The pericardium may be aspirated through an intercostal space near the lower part of the sternum without injuring the heart; though there is always the possibility of puncturing the pleura, even in the fifth interspace on the left side, because of the rather irregular limits of the pleura. The suggestion that the sternum be trephined in order to avoid the pleura is hardly practical as aspiration with a fine needle will probably not harm the pleura, unless there is marked sepsis and in such instances aspiration should be for diagnostic purposes only and should be followed immediately by incision and drainage. The internal mammary artery must be borne in mind, as it lies about one-half an inch from the external border of the sternum. The spot usually utilized for aspiration is the fifth left intercostal space about three-fourths of an inch from the sternum. The needle is passed backward and to the right and, if used for curative purposes, is connected with a bottle in which there is negative pressure, but for diagnostic purposes a syringe is all that is necessary. A small trocar and cannula are more satisfactory than the ordinary aspirating needle, particularly if the effusion is not septic and if it is merely intended to draw off the fluid and relieve the mechanical pressure.

If the pericardium is to be opened, about an inch of the cartilage of the left fifth rib, together with a small portion of the adjoining sternum is removed with bone forceps. The internal mammary had best be tied at the upper and lower border of the incision. After dividing the triangularis sterni muscle the pleura is identified if possible and gently pushed outward. If this cannot be done and if the pleura is opened the incision into the pleura should be closed by sutures. The pericardium is transfixed with a tenaculum or with a suture

and incised after protecting the tissues in the neighborhood from the fluid by gauze packing. A soft rubber tube, or a tube of rubber dam, is carried to the posterior part of the pericardial cavity and fixed in position by a suture in the edge of the pericardium which transfixes the tube. The rest of the wound, particularly over the pleura, should be packed with a gauze tampon to protect it from absorption of the septic fluid from the pericardium.

THE HEART

Surgery of the heart consists in repairing wounds. While experimentally some work has been done on the valves of the heart it has not so far been sufficiently promising to be even suggestive of clinical application. Exposure of the heart depends to some extent upon the location and the character of the wound. The resection of two to four ribs and costal cartilages over the heart, or the formation of a hinged flap consisting of the skin, ribs, muscle and periosteum and sometimes including a portion of the sternum, may be used. Robinson suggests as a satisfactory method of exposure of the heart an intercostal incision and the use of rib spreaders. If the ribs are resected subperiosteally they will regenerate and it is usually unnecessary to divide the sternum. A hinged flap with the hinge outward and including the skin, ribs and the periosteum of three of the ribs usually meets the indication. The suggestion of Godlee[5] that the skin be reflected in one flap and the muscles, ribs and periosteum in another may afford a more satisfactory exposure. A flap of horseshoe or rectangular shape with the base external three inches in width and extending to about half across the sternum is outlined. The costal cartilages and the inner portion of the fourth, fifth and sixth ribs are included in the flap. The cartilage is separated close to the sternum, separating first the fourth, then the fifth and sixth. The ribs themselves are cut with bone forceps about three or four inches from the sternum. After ligating the internal mammary artery at the upper and lower margins of the flap the flap is raised and retracted outward forcibly. Care should be taken to avoid injuring the pleura if possible, but if it is injured the wound may be sutured along with a margin of the lung and the pleural wound covered with moist gauze held firmly in position until the completion of the operation. A pneumothorax lessens the force of the heart and may make the suturing of the heart easier. The pericardium which is exposed is incised vertically and lateral incisions may be made if necessary to obtain more room. The wound is sought for and care is taken to prevent aspiration of air into the heart. It may be necessary to resort to different methods in order to insert the sutures. Sometimes the heart can be gently grasped with the hand of the surgeon while the suture is being placed. If the wound is large and has been temporarily occluded by a blood clot, sutures can be inserted when the blood clot is in position, but if the blood clot is dislodged and hemorrhage occurs the wound is temporarily closed by plugging it with the finger or thumb with one

[5]Oxford Surgery, iv, 174.

hand while the sutures are being inserted with the other hand. Tanned catgut may be used for the suture material, though on account of the constant motion of the heart and the tendency to loosening of the knot, linen or silk is preferable. The sutures should always be interrupted and introduced with a full curved needle. While the sutures are being placed the heart is steadied either by the left hand of the surgeon or by silk tractor sutures that are inserted near the apex of the heart. Care must be taken to avoid injury to the coronary arteries or their branches. It must be remembered that the heart can be completely stopped if necessary for a period of one minute or slightly longer if the hemorrhage is of such a character as to demand this. Pressure

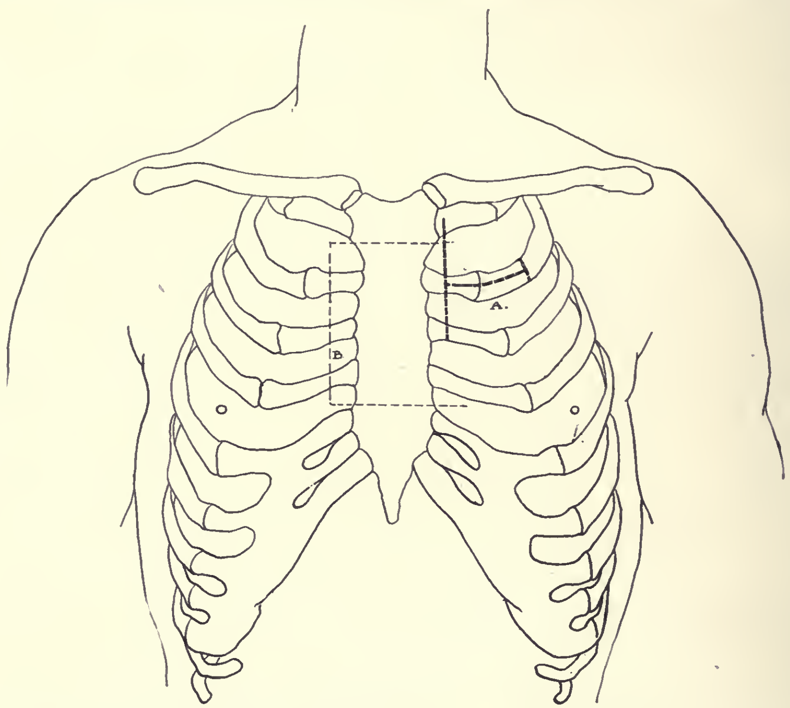

Fig. 443.—Lines of incision for the operation of Trendelenburg for pulmonary embolism.

around the base of the heart with a rubber tube, or a soft clamp on the superior and the inferior vena cava at the base of the heart will, of course, render the heart bloodless but they are dangerous procedures and should not be resorted to unless it is apparent that the wound cannot be sutured in any other way. If the pleura has been injured and has not been sutured it should be carefully closed by sutures. It is best to drain the pericardium by rubber tissue or a small soft rubber tube, which is fixed to the lower angle of the incision in the pericardium by a suture. The pericardium is united with a continuous suture of silk, linen or tanned catgut. The flap of ribs, muscles and skin is replaced, drainage being brought out at the lower border of the wound. The sutures into the periosteum, connective tissue and muscle will hold the deep

portion of the flap in position. The skin is sutured accurately in the usual way. Too much pressure must not be placed over the flap, as it may cause it to press too greatly upon the heart.

After the history of an injury with marked effusion into the pericardium which necessitates operation the pericardium should be opened even though there is no visible sign of injury. Death has resulted from rupture of the heart muscle due to the trauma inflicted by a bullet upon the pericardium which was not itself penetrated.

Trendelenburg has devised an operation for pulmonary embolism, in which the exposure is somewhat similar to the exposure for suturing the heart. He makes a horizontal incision about four inches long on the second rib on the left side, beginning at the border of the sternum and dividing the skin, fascia and pectoral muscle. At the inner extremity of this incision there is a perpen-

Fig. 444.—Incision into the pulmonary artery, which is held open by self-retaining forceps. (Trendelenburg.)

dicular cut which begins just below the left sternoclavicular articulation and goes downward to the lower border of the cartilage of the third rib one inch from the border of the sternum (Fig. 443). In this way the internal mammary artery is avoided. Two triangular flaps are made by this T-shaped incision and they are reflected. The second rib is isolated for four and one-half inches and divided at the outer end of the incision. The rib is raised subperiosteally and twisted from its cartilage, which is also removed. The third cartilage is divided to give more space and if the pleura has not been opened by this time a T-shaped incision is made which corresponds to the original incision. The lung is permitted to collapse and the pericardium is exposed. The phrenic nerve and the pulmonary vessels are easily seen and the pericardium is divided just internal to the phrenic nerve. The wound is extended upward and backward until the entire upper half of the pericardium is incised. The lower part of the pericardium is not cut and the heart is left in its normal position. All this is supposed to be done in five

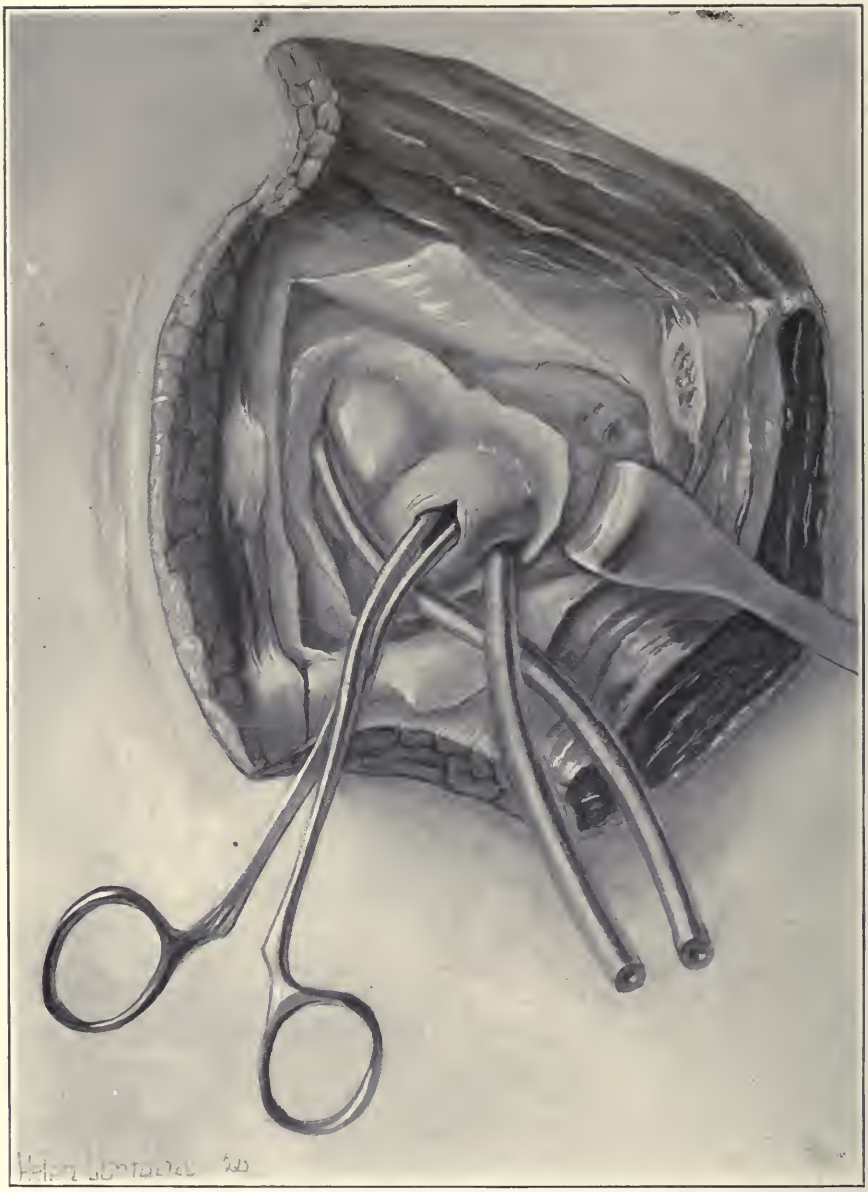

Fig. 445.—The circulation at the base of the heart has been temporarily controlled with a rubber tube. Forceps are withdrawing the embolism from the pulmonary artery. (Trendelenburg.)

minutes. Intratracheal insufflation anesthesia should be used if possible, though it is not necessary. With the instruments that have been devised by Trendelenburg a rubber tube is quickly drawn through the transverse sinus of the pericardium surrounding the ascending aorta, and the pulmonary artery is pulled up for compression immediately before the surgeon incises the pulmonary artery. A thin layer of fat with the visceral layer of pericar-

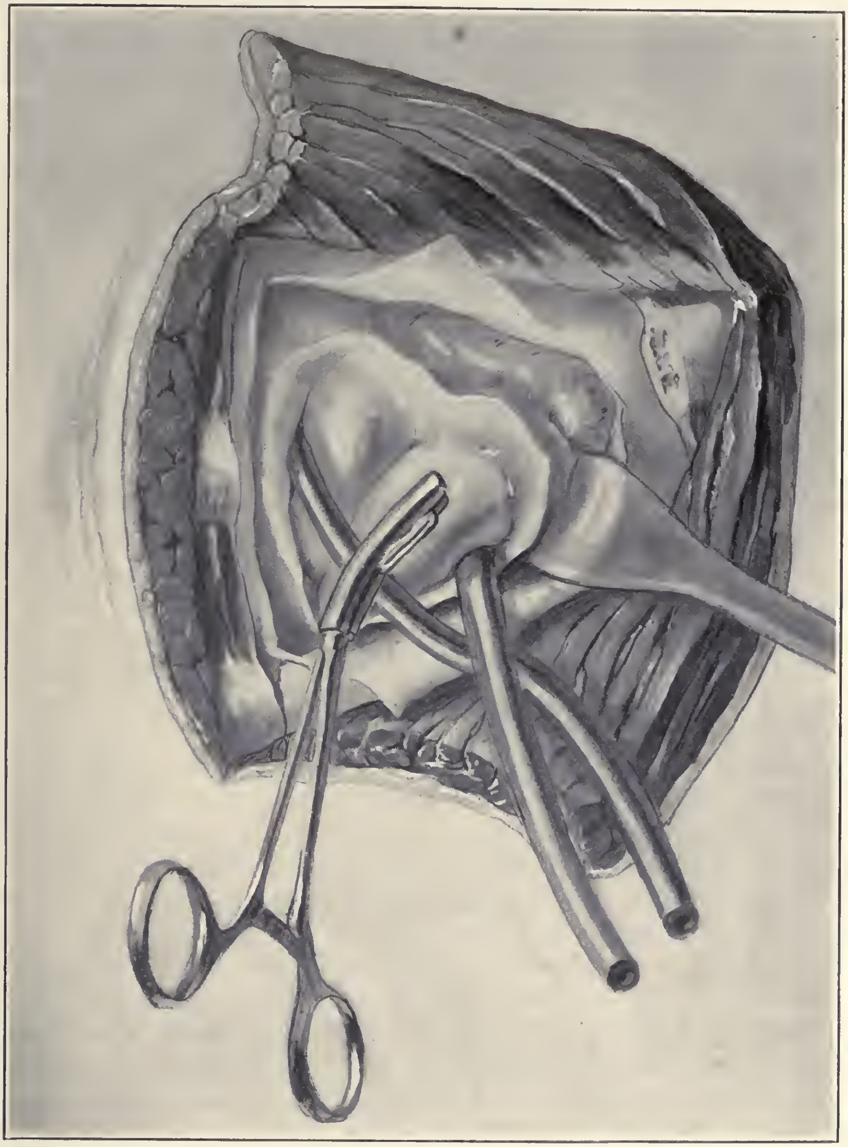

Fig. 446.—The incision in the pulmonary artery is closed by a clamp and sutured with fine silk. (Trendelenburg.)

dium is torn through and an incision half an inch long is made in the pulmonary artery (Fig. 444). With a special curved blunt forceps introduced into the main trunk of the pulmonary artery and then into its branches the embolus or thrombus is grasped and extracted (Fig. 445). This must be done in forty-five seconds, because interruption of the general circulation is not tolerated longer. The margins of the wound in the pulmonary artery are lifted by special forceps and closed by a clamp after which the elastic compression around the aorta and pulmonary artery is relaxed (Fig. 446). The

circulation is thus reestablished and the heart beats violently if it has not altogether ceased to beat. The constriction can be tightened again and another search made for the embolus, though the circulation must not be cut off for more than forty-five seconds at any one time. The wound in the pulmonary artery is closed while the clamp partly, but not completely, constricts the pulmonary artery. The wound is sutured with fine silk. The pericardium and chest wounds are closed in the usual way. Twelve cases have been operated upon in Trendelenburg's clinic without a permanent recovery, though one lived for four days and another died from pneumonia on the fifth day after operation. In view of the gravity of the situation, however, it may be possible that under ideal conditions such an operation can be undertaken successfully.

PARALYSIS OF MUSCLES OF THE THORAX

Occasionally in order to secure rest of the lung and to paralyze the half of the diaphragm under a diseased lung, the phrenic nerve is cut. In persistent hiccough, which it can be demonstrated occurs only on one side, the phrenic nerve is sometimes exposed and infiltrated with 60 per cent alcohol. The phrenic nerve is also supposed to carry some sensory fibers which register pain in the shoulder in some cases of chronic tuberculosis. Injection of 60 per cent alcohol is more desirable than a complete division of the nerve, as it may not put the nerve completely out of commission and yet, will interfere with its function sufficiently long to give rest. To expose the phrenic nerve the head is turned to the opposite side and an incision made along the posterior border of the sternomastoid muscle. After dividing or retracting the external jugular vein the sternomastoid is retracted inward and the phrenic nerve is found coursing downward and forward on the scalenus anticus and forming an acute angle with a portion of the brachial plexus.

Paralysis of the serratus magnus may occur after operations in the axilla in which the posterior thoracic nerve is injured. After operations on the neck in which the spinal accessory nerve is cut the trapezius is partly paralyzed. It is not often that these two muscles are paralyzed at the same time from surgical operations, because the nerves that supply them lie in regions of the body that are not likely to be involved by the same disease. The modern technic for operations for cancer of the breast tends to avoid injury to the posterior thoracic nerve and except in malignancy of neck tumors the spinal accessory can usually be spared in dissection of the neck. In paralysis of the serratus magnus the posterior border of the scapula tends to flare upward and may produce considerable disability and deformity. This can be partially corrected. A perpendicular incision along the vertebral border of the scapula from its upper to its lower angle. The trapezius and major rhomboideus muscles are divided and the latissimus dorsi is retracted downward. The periosteum is exposed along the border of the scapula and reflected along with its attached muscle on the external surface and likewise on the internal

surface, and the excess of periosteum on the internal surface of the scapula is excised. The sixth and seventh ribs are denuded of periosteum about two and three-fourths inches from the spine, denuding the seventh rib one-half an inch farther out than the sixth. Holes are drilled through the posterior border of the scapula and wire sutures are passed through these holes and around the sixth and seventh ribs. The wires are twisted and cut short and the periosteum is reflected over them as far as possible. The inner portion of the wound is retracted and the long muscles of the back are exposed, and a long thick flap of muscle with its pedicle below is dissected out and sutured at the upper angle of the scapula to the periosteum and supraspinatus muscle. Duval, who devised this operation, advises a plaster of Paris dressing for about forty-eight days.

A somewhat better procedure consists in a transplantation of muscles if this can be done. Katzenstein has suggested the transplantation of portions of the trapezius muscle and of the pectoralis major in paralysis of the serratus. When the trapezius is completely paralyzed the upper margin of the latissimus dorsi is exposed and a flap split off from this muscle near its insertion into the humerus so that the flap has a posterior pedicle. The free end of this is then sutured to the posterior surface of the scapula so as to take the place of the lower fibers of the paralyzed trapezius. A flap can be turned over from the opposite healthy trapezius and sutured to the middle portion of the posterior border of the scapula taking care to preserve its nerve supply by severing the outer end of the flap along the clavicular insertion. Finally, another flap can be taken from the middle of the trapezius with its base toward the spine and sutured to the border of the scapula. In paralysis of the serratus magnus or the serratus and the trapezius muscles, the spinal origin of the rhomboid muscles can be divided and transplanted to the lower vertebrae to make them assist the serratus magnus muscle. The tendon of the major pectoral may be divided at its insertion into the humerus and sutured to the axillary border of the scapula. In paralysis of the trapezius a free transplant of fascia according to the method of Rothschild can be done. Here a strip of fascia lata about eight inches long and two inches wide is taken from the thigh after exposing the posterior border of the scapula by an incision from its upper angle down to the first lumbar vertebra. One end of the strip of fascia is sutured to the supraspinatus muscle and fascia over it and the other end to the latissimus dorsi and muscles near the spine. The fascial transplant must be put on tension before being sutured in order to see that the scapula on the paralyzed side is pulled to the level of the scapula on the normal side and that its posterior border is parallel to the spine. To prevent adhesions between the fascia and skin a small opening may be made through the paralyzed trapezius near the scapula and the lower portion of the transplant carried beneath the muscle to the point where it is sutured into the structures around the origin of the latissimus dorsi.

In deltoid paralysis Dean Lewis operates by transplanting muscle to overcome this defect. He makes an incision from about the middle of the outer

border of the trapezius to a point at the junction of the middle and lower thirds of the deltoid muscle. The clavicular, acromial, and a portion of the spinous attachment of the trapezius muscle are divided, the paralyzed deltoid is separated from the clavicle and spine of the scapula and turned down and the sheath of the long head of the biceps is incised and its tendon plicated so as to bring the head of the humerus into proper position. The flaps from the trapezius muscle are now sutured to the capsule of the shoulder joint where it is attached to the humerus and the deltoid muscle which has been turned down is sutured over the trapezius as high up as possible while the arm is abducted. The upper part of the wound in the skin is sutured transversely to the direction of the incision so as to make some tension on the tissues around the shoulder joint. This makes a T-shaped scar. The arm is immobilized in plaster of Paris for about four weeks at an angle of about 100 degrees and is then gradually taken down.

THE SCAPULA AND CLAVICLE

Excision of the scapula may be necessary on account of malignant disease or from severe infection, which produces osteomyelitis. When it is done for osteomyelitis the operation can be conducted subperiosteally according to the method of Ollier, by an incision along the entire length of the spine of the scapula through which the periosteum and the muscles are raised from the spine of the scapula. Then another incision is made along the posterior border of the scapula and the periosteum and its attached muscles are raised. The posterior border of the scapula is retracted strongly away from the chest and the periosteum of the under surface of the scapula is separated from the bone until the neck of the scapula is reached. The acromioclavicular joint is divided from below upward and the capsule of the shoulder is cut. The base of the coracoid process is severed with bone forceps and the head of the scapula is left in position if possible, dividing the neck of the bone so as to interfere as little as possible with the shoulder joint. Portions of the scapula may be excised by incisions placed according to the indications of the disease. In malignant disease of the scapula, however, the bone together with much of its attached structures must be removed. Here the incision is first made from the apex of the axilla down the arm for about three inches along the inner and posterior border of the coracobrachialis muscle. The coracoid process is exposed by raising the anterior axillary fold and the muscles inserted into this process are divided close to the bone. The axillary artery is fully exposed and the subscapular artery is doubly ligated and divided close to the axillary artery. This wound is protected with gauze and the patient is turned on the opposite side and an incision made along the whole length of the spine of the scapula to the point of the acromion process. Another incision at a right angle to this runs along the posterior border of the scapula. The skin flaps are retracted along with the subcuticular tissue. Some of the muscle that arises from the scapula is divided, leaving as much muscle attached as seems wise. The deltoid and trapezius muscles are split along the junction of their

scapular and clavicular portions and divided so as to remove a sufficient quantity of the muscle along with the scapula to make it reasonably certain that all of the disease is included in the removed tissue. The clavicular part of the deltoid muscle can be preserved. The tendons of muscles which are inserted into the upper end of the humerus are divided and the capsule of the shoulder joint is opened. The long head of the triceps, which is in the upper and outer part of the wound under the head of the humerus, is isolated and severed carefully so as to avoid injuring the circumflex nerve. If the acromion process is to be preserved it may be divided with forceps or a saw. If it is near the disease it should be removed along with the rest of the scapula. The portion of the trapezius muscle that is to be removed is divided, inserting the finger under it while the muscle is cut with scissors or a knife. The omohyoid muscle, which arises from the upper portions of the neck of the scapula, is detached and the suprascapular artery is divided and, at the outer upper angle of the scapula, a branch of the transverse cervical artery is cut. The rhomboideus muscle and the serratus magnus are severed. The capsule of the shoulder joint is completely divided and the scapula is removed. The upper part of the capsule of the shoulder joint may be sutured to the clavicle with wire sutures. The long head of the biceps may also be sutured to the clavicle and if a part of the deltoid muscle has been preserved this may be sutured to the rhomboideus and to the trapezius.

Excision of the clavicle may also be done for osteomyelitis or for malignancy. When this bone is to be removed because of osteomyelitis, an incision is made along the subcutaneous portion of the clavicle, and the periosteum is divided to the bone and carefully separated with a periosteal elevator, particularly behind and below where important structures are in close contact with the clavicle. The bone may be divided in its middle with forceps or a wire saw and each end removed separately, or it may be severed from the joint at the outer or inner end and separated in this manner.

In malignant disease, however, a more radical operation is necessary. An incision is made along the length of the bone through the skin and additional incisions at right angles to the ends of this long cut may be necessary for satisfactory exposure. After the skin and subcuticular tissues have been dissected from the clavicle and its growth, the outer portion of the sternomastoid muscle is exposed and divided after inserting the finger under the muscle to protect the deep structures. The insertion of the trapezius muscle is similarly divided at the outer portion of the clavicle and the major pectoral and deltoid attachments are likewise severed. The ligaments at the outer end of the clavicle are divided, severing first the ligament to the acromion process and then that to the coracoid. The acromioclavicular joint is completely severed and the outer end of the clavicle is pulled forward and upward. The tissues are then dissected from the posterior portion of the clavicle up to the sternoclavicular joint, taking care to avoid injury to the subclavian vein. The wound is closed in the usual manner and the shoulder and arm are immobilized by an abundant dressing.

CHAPTER XXI

OPERATIONS ON THE MAMMARY GLAND

The mammary gland is subject to disease but the results of operations upon it are, as a rule, satisfactory if properly performed and at an early stage of the disease.

Inflammation of the mammary gland that results in suppuration requires incision and drainage as in abscesses elsewhere. These incisions should be made along the periphery of the gland, radiating from the nipple to avoid injury to the milk ducts that converge at the nipple. Large single abscesses should be opened at the most dependent portion of the breast and abundant drainage provided by a single large tube or by multiple tubes. The breast is gently compressed by large dressings, as relaxed tissue without the application of moderately firm pressure tends to form pockets. In some multiple abscesses drainage and incision are ineffectual and it is then necessary to excise the breast. This may be done in such a manner as to preserve the nipple and a flap of skin covering the upper portion of the breast. Where this operation is necessary multiple abscesses have so riddled the breast that there is but little gland tissue left, and the operation is in the true sense of the word a conservative one. Here the breast is approached from the lower and outer portion, as in the Warren operation, and is first dissected from the pectoral muscle by an incision along the inner, lower and outer quadrants, protecting as far as possible the wound from the pus. This can be done by enveloping the breast with moist gauze or a wet towel, taking care that the pus from the sinuses has been irrigated carefully before the incision is made. The breast is lifted up and the bleeding vessels are clamped and tied. The wound over the pectoral muscle is protected by layers of moist gauze and the breast is dropped back on the moist gauze. An incision is then made in the skin to include if possible the nipple and an upper flap of skin. The skin covering the lower and outer quadrants of the breast through which there has been gravity drainage is left attached to the diseased mammary gland and is removed with the breast. The skin flap is reflected to the upper limits of the mammary gland including as much of the attached fat as possible. The upper skin flap is retracted strongly and the breast severed from its attachments near the sternum and outward toward the axilla. All bleeding points are carefully tied and drainage is established by a tube at the outer portion of the wound, or, preferably, through a stab wound just below the outer portion of the wound. The wound is closed with sutures of interrupted silkworm-gut.

Operations for benign tumors of the breast are planned according to the size and character of the tumor. If there is a reasonable suspicion that

the tumor is malignant, and always in exploratory operations in which malignancy is expected, the incision should be made directly over the growth regardless of the probable cosmetic effects of the scar. As little raw surface as possible should be exposed to the chance of contact with cancer cells. Such operations as the Warren operation, which turns up the breast by an incision along its lower margin and approaches the tumor from below, may expose the cells of a malignant tumor to inoculation over an extensive raw surface. At the same time the incision is of such a character as to make it difficult satisfactorily to perform a radical operation if the neoplasm should prove to be definitely malignant. Furthermore, one of the chief principles that Halsted and others have demonstrated in radical operations for cancer is violated. Cancerous tissue should be removed in one mass, and when the breast has been previously separated from the pectoral muscle the lymphatics that carry cancer cells toward the axilla have been divided.

The Warren operation is a modification of the original incision suggested by T. Gaillard Thomas. In Warren's original communication[1] he desired an incision quite similar to that of Thomas, which is beneath the breast. Later,[2] however, he places the incision along the outer hemisphere to coincide with the edges of the breast and he finds that it gives free access to the upper hemisphere and at the same time to the outer portion of the breast, which are regions that are more frequently the site of tumors than the inner quadrants. The incision may be prolonged upward toward the axilla in such a way as to throw the breast over toward the sternum and expose freely even the inner regions. Care is taken not to divide the thoracic arteries though there is sufficient nutrition from the internal mammary perforating branches. The dissection is carried down to the outer edge of the major pectoral muscle and uncovers the fascia which lines the posterior surface of the mammary gland. This fascia is dissected from the deep pectoral fascia that covers the pectoralis major, and if the line of cleavage is followed the dissection is quite easy as between these two layers there is only loose connective tissue. The breast is so manipulated with the left hand as to expose its under surface completely. If a growth is present it is excised in a wedge-shaped piece of tissue, the apex of the wedge being toward the nipple. The incision is carried through to the fatty tissue in front of the gland beneath the skin, but this subcutaneous fat is not removed as it aids in reconstructing the breast and prevents depression. No attempt should ever be made to shell out the tumor because it is sometimes difficult and is always likely to leave a portion of the capsule of the tumor behind, and there will be recurrence. Besides, there may be small tumors or matrices of tumors in the breast tissue adjoining the main tumor. If there are many small cysts or if the operation is for chronic cystic mastitis of one portion of the breast the rest of the breast should be explored after the diseased segment

[1]Jour. Am. Med. Assn., July 15, 1905.
[2]Ann. Surg., June, 1907, p. 810.

has been removed. This is done by radiating incisions, beginning about the center of the breast and carried to the periphery like spokes from a wheel. Small cysts can be excised with a knife or scissors but those smaller than a pea are merely opened and, according to Warren, do not require removal. After removing the diseased segment usually two or three incisions are sufficient for exploratory purposes. Exploratory incisions hardly require sutures because they drop together when the mammary gland is replaced. When a segment is removed, however, or tissue of any amount is excised the wound is closed with catgut sutures. If in operations for chronic cystic mastitis the nipple is inverted this should be corrected by freeing the adhesions of the nipple and placing a purse-string suture under the nipple to evert it. The purse-string suture should be of tanned or chromic catgut. The sutures are placed first on the portion of the gland nearest the skin, then the capsule and the posterior part of the gland are sutured with interrupted catgut sutures. The gland is replaced and anchored along the edge of the fascial and pectoral muscle with a few interrupted catgut sutures. A second row of catgut stitches

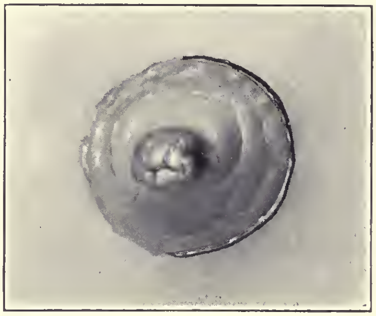

Fig. 447.—Incision of Dean Lewis for removal of the mammary gland in intracanalicular papilloma.

may be taken through the superficial fascia before closing the skin, though this is not always necessary. The wound is closed by a continuous mattress suture of fine tanned catgut or by silk or silkworm-gut if it is preferred. Drainage is instituted by a small tube at the outer upper angle of the wound, as the large raw surface nearly always results in the accumulation of bloody serum.

This operation should not be done where there is any reasonable suspicion of malignancy. Where there seems to be no doubt about the benign nature of the growth and where chronic cystic mastitis appears localized to one quadrant of the breast the operation of Warren has a distinct field of usefulness.

Excision of the breast, particularly where there is a small growth which causes a bleeding nipple, can be done with but little deformity by the operation of Dean Lewis.[3] Bleeding nipple occurs most frequently after intracanalicular papilloma and sometimes after certain types of chronic cystic

[3]Surgical Clinics of Chicago, Feb., 1917, Philadelphia, W. B. Saunders Co., pp. 117-124.

mastitis. There should be no reasonable doubt that the growth is benign. Bloody discharge from the nipple is exceedingly rare in any cancer but if cancer is present the other signs, such as retraction of the skin and comparative immobility of the growth should suggest the correct diagnosis. In a persistently bleeding nipple even without a palpable growth it may be presumed that there is an intracanalicular papilloma. Usually there is a small growth rather superficial and beneath the nipple or the areola of the nipple. The next most common cause is chronic cystic mastitis. Lewis employs an incision at the junction of the areola with the skin to the inner side of the nipple (Fig. 447). The areola is dissected up and the ducts are cut as they enter the nipple. The tissues of the mammary gland are gradually pulled out while the dissection is carried between the mammary gland

Fig. 448.—The mammary gland is being freed. (Dean Lewis.)

and the fat (Fig. 448). The whole mammary gland can be removed in this way. After the operation is completed the wound is closed by a series of purse-string sutures of catgut placed from below upward in the fat that was adjacent to the breast. With three or four purse-string sutures the tissues are so reconstructed as to leave but little deformity (Figs. 449 and 450). The flap of the areola is sutured in position and the wound is not usually drained, though there is considerable discharge of serum for some days after the operation. Lewis thinks that perhaps a small cigarette drain would be advisable.

Hernia of the breast is a condition that occasionally occurs when the fascia around the areola and the nipple gives way and allows a bulky protrusion of the mammary gland substance. M. L. Harris[4] operates under local

[4]Surgical Clinics of Chicago, October, 1917, Philadelphia, W. B. Saunders Co., pp. 959-963.

anesthesia by using four small incisions radiating from the nipple, so placed as to divide the circumference of the areola into four equal parts. These incisions are about a third of an inch in length and extend through the skin just within the ring of the subcutaneous fascia through which the breast tissue tends to escape. A long straight needle threaded with silk is inserted through

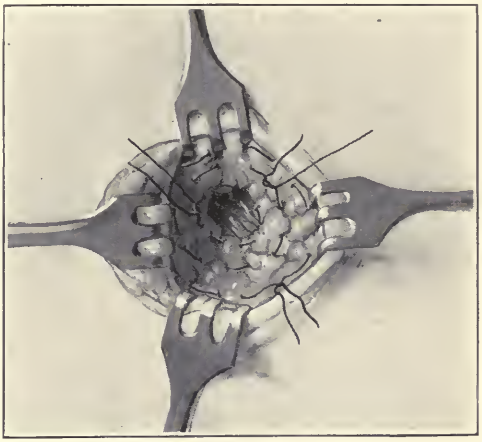

Fig. 449.—The mammary gland has been excised and pursestring sutures are inserted in the surrounding fat. (Dean Lewis.)

one of the incisions, picks up the edge of the ring of the fascia, and is brought through the neighboring incision, several bites being taken in the ring. After bringing out the needle through an adjoining incision it is reinserted in a similar manner through each quadrant of the areola, taking

Fig. 450.—The purse-string sutures have been tied, so obliterating the cavity left by removal of the mammary gland. (Dean Lewis.)

care to catch as many bites as possible in the ring of fascia which permits the hernia. When the needle has returned to the point of beginning three more sutures are placed in a similar way, each one a little farther out than the preceding suture. After all are placed they are drawn up snugly and narrow the

ring to a diameter that leaves it just large enough for a free passage of the milk ducts to the nipple. The threads are then tied and the ends cut short. The incisions are closed with fine silk or fine silkworm-gut.

When there is suspicion of malignancy a direct incision to the tumor should always be made so as to go through as little tissue as possible. The incision, which is radiating, is carried down to the neighborhood of the tumor and then the growth is carefully approached to avoid incising it until a view can be had of the tissues in its immediate vicinity. Often if it is cancerous the infiltration is detected before the main growth is actually opened. If it is a cyst, and particularly the "blue dome" cyst of Bloodgood, a careful incision gives the characteristic appearance before the cyst is opened. If the growth is still suspicious and a frozen section is necessary to decide the diagnosis, a small piece of tissue is removed from the suspicious portion. The raw surface should then be immediately cauterized with the electric cautery or mopped out with carbolic followed with alcohol. If the growth proves to be benign the whole raw surface is excised as in a debridement operation, for the cauterized raw surface will not heal satisfactorily. The growth should be removed along with surrounding healthy mammary tissue and after careful hemostasis the wound is closed with catgut sutures, taking particular care to approximate the deep layers of the mammary gland accurately to avoid leaving a dead space. The superficial portions of the mammary gland are sutured separately and the skin is closed with a fine subcuticular suture of silkworm-gut or interrupted sutures of fine silk. If a subcuticular suture is used it is best to insert a few strands of silkworm-gut at one end of the wound to conduct away the serum and broken down fat that accumulates after these operations.

If the growth proves malignant the skin wound is closed with forceps after packing the cavity with gauze and a radical operation for cancer of the breast is done.

There are occasional indications for removal of the mammary gland with the nipple but without the necessity of a radical operation, as after tuberculosis or large multiple benign tumors, or in extensive chronic cystic mastitis without malignant degeneration. This is done by an oval or elliptical incision whose axis is between the axilla and the navel. The skin incisions are dissected up on each side, retaining as much fat under the skin as possible and at the same time bearing in mind that the edges of the mammary gland often extend farther than they appear to extend. After reaching the pectoral fascia the breast is dissected preferably from below up and then from within outward and is completely removed. The skin wound is closed in the usual manner.

The radical operation for cancer of the breast was first put on a satisfactory basis by the work of Halsted, of Johns Hopkins. His analysis of the statistics of Billroth and others showed that there was a local recurrence in the scar or in the skin near the scar in from 80 to 90 per cent of the cases. Halsted became convinced that the operation should be so planned as to remove not only the breast but the adjacent structures including a wide ex-

cision of skin, both pectoral muscles, and the contents of the axilla in one mass. Willy Meyer, of New York, independently employed the same principles about the same time and described an operation in which he began dissection at the axilla instead of at the inner portion of the breast as in the Halsted operation.

In the original operation of Halsted an incision was made which surrounded the breast, taking as much skin as possible. The incision was carried at once through the fat, was then prolonged at a tangent to the inner portion of the incision and carried over the pectoral muscle to a point about opposite the apex of the axilla. This incision, however, has been changed by Halsted so that it never goes down the arm, as was originally recommended, and consequently the triangular flap of skin has been abandoned. A short vertical cut to the clavicle is made instead. If the surrounding incision is extensive and wide this vertical incision is unnecessary. The abandonment of the incision down the arm avoids the contraction of the scar through the axilla, which not only interferes with the motion of the arm but sometimes produces discomfort. The incision in the skin, then, is placed to surround the breast with the malignant growth, and not the nipple, as the center. A vertical cut is made to the clavicle and another under the axilla if necessary to expose the axilla satisfactorily. The origin of the major pectoral from the ribs is divided and the clavicular portion of the muscle is split to a point about opposite the scalene tubercle of the first rib where it is cut across up to the clavicle, thus exposing the apex of the axilla. The loose tissue under the clavicular portion of the pectoral major is dissected from the muscle and is included in the mass to be excised, for this tissue contains many lymphatics and may be infected with cancer. The insertion of the pectoralis major is severed close to the humerus, then the insertion of the pectoralis minor, and the whole mass, including the skin, breast and muscle, is raised and stripped from the thorax as close to the ribs as possible. The minor pectoral muscle is included in the mass to be removed. The axilla is dissected from within outward and from above downward, using a sharp knife and stripping the axillary vein clean. After clearing the axillary vein the axilla is dissected on its inner wall and then its posterior wall from within outward. The subscapular vessels are usually clamped and divided. The subscapular nerves may be divided or saved depending upon the indications at the time. The mass is completely removed by severing the outer and lower attachments of the fascia of the pectoral muscles. Halsted then advises an incision along the posterior margin of the sternomastoid muscle, which divides a few of the fibers of the muscle and exposes the junction of the internal jugular and the subclavian veins. The omohyoid muscle is divided and retracted and the supraclavicular fat is removed by dissecting downward and outward from the junction of the internal jugular and subclavian veins. The infraclavicular fat is dissected up from below. By elevating or lowering the shoulder the clavicle can be raised or lowered and the tissue which binds the subclavian vein to the clavicle can be put on a stretch and

removed while the finger is passed beneath the clavicle. Any fat or overlooked fascia is demonstrated and removed. The fat along the inner and posterior border of the scapula between the serratus magnus and the subscapular muscles is also removed. The wound in the neck is sutured. Particular care is taken to suture the skin around the axilla while the arm is held outward and upward. The flap of skin next to the axilla is so manipulated that it will line the apex of the axilla and protect the vessels. This presents later axillary contraction. The lower portion of the wound is approximated as much as possible with sutures. The rest of the raw surface is covered with Thiersch skin grafts.

The operation of Halsted has given results that were greatly superior to any other operation used at that time. It was founded on an accurate conception of the pathology of cancer and the anatomy of the tissue involved.

Fig. 451.—Lines of incision for operation of Jackson for cancer of the breast.

There are apparently advantages, however, in planning the operation so that the dissection can be begun at the axilla instead of at the upper and inner border of the mammary gland. The operation of Jackson embodies this principle and has given excellent results. Here an incision is made in such a manner that a quadrangular flap of skin is left with its base from the clavicle near the shoulder to a point near the sternum (Fig. 451). After excision of the mammary gland with the pectoral muscles and the contents of the axilla, this quadrangular flap is turned down in position, so covering the wound.

There is serious objection to any operation for malignant growths that is planned with the closing of the wound as one of the chief objects in view. As Halsted has said it would be better to have one surgeon remove the

cancer and another to close the wound, so the former would be unhampered by the thought of covering the raw surface after he had extirpated the disease.

In recent years I have done with much satisfaction the operation described by the late W. L. Rodman. This operation is based primarily upon the principle of extirpating the diseased tissue in one mass. Sampson Handley's researches have shown that cancer not only grows along the main lymphatic trunks, but radiates in the subcutaneous tissue from the original focus. The cancer cells instead of migrating, grow from the base in long columns and the cells nearest the original focus of disease may perish and obliterate the lymphatic channels in which they grew. A strip of subcutaneous tissue radiating from the original focus of cancer may frequently be found to contain cancer cells not near the tumor, but at a point several inches from the growth. It has also been demonstrated that cancer of the breast

Fig. 452.—Lines of incision for operation of Rodman for cancer of the breast.

rarely if ever metastasizes through the blood stream, but uses the lymphatic channels and continuity of tissues for growth. Metastases in the liver, for instance, probably come from the breast through the tissues around the ensiform cartilage and thence to the liver through the lymphatics. Metastases in the bones of the vertebræ come to their destination through the subcutaneous and deeper tissues around the chest wall. The object of the operation, then, is first of all to remove this potentially cancer bearing tissue and to remove it in one mass, so that the edges of the specimen will contain healthy tissue and will surround all the cancer cells.

In the operation of Rodman a straight incision is made from about an inch below the clavicle downward and outward, two inches from, and parallel to, the sulcus between the deltoid muscle and the upper part of the major pectoral. This incision extends well below the free edge of the pectoral

muscle and is about six inches in length, sometimes longer. The incision is carried down through the skin to the fascia covering the pectoral muscle. It should not be placed too close to the arm because of the possible discomfort of the subsequent scar (Fig. 452). The outer portion of the incision is strongly retracted by a broad retractor and the index finger of the left

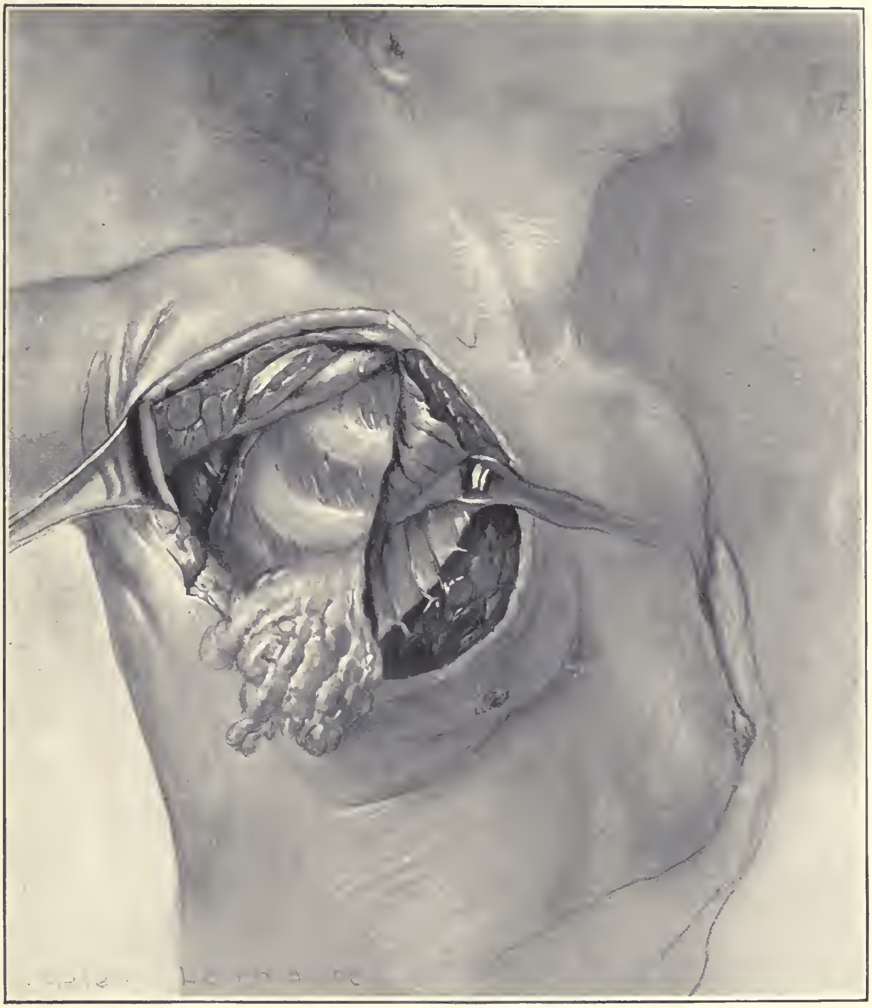

Fig. 453.—The axilla is exposed and dissected from above downward, leaving the long subscapular and the posterior thoracic nerves. (W. L. Rodman.)

hand is introduced under the major pectoral near its insertion and the muscle is divided close to the humerus. Sometimes a portion of the muscle near the clavicle can be left and will not interfere with the dissection, or with the chances of recurrence, though if the growth is near the muscle it will be safer to remove the whole pectoralis major. While still strongly retracting the outer edge of the incision in the skin, the minor pectoral mus-

cle is identified, separated from its fascia, and divided in a similar manner. The long thoracic artery runs in the fascia parallel with, and just below, the tendon of the minor pectoral and unless this fascia is separated from the muscle before the tendon is divided this artery may be injured. The acromiothoracic artery is just above the tendon and this too should be protected. Both of these arteries will be easily avoided by dissecting the fascia from the tendon of the pectoralis minor before the finger is inserted beneath it, then lifting up the tendon strongly and dividing it close to its insertion into the coracoid process. The outer portion of both pectoral muscles is strongly retracted inward and the axilla is dissected by opening the costocoracoid membrane and beginning the dissection at the apex of the axilla around the axillary vein. The cephalic vein at the upper and outer part of the wound should not be injured. Dissection is made from above downward, removing the fat and fascia carefully from the vein, using a sharp knife near the vessels and then gauze for blunt dissection. Rodman advises the use of gauze entirely in the upper third of the axilla, though with a careful exposure dissection with a sharp knife is more satisfactory. As the axillary vessels are cleared from above downward the acromial, alar thoracic, and the subscapular branches of the axillary artery are encountered in the order named from above downward. These arteries with their accompanying veins are doubly clamped and divided. The large lymphatic glands are usually found at the base of the axilla. The whole contents of the axilla, including the glands, is carefully dissected from the axillary walls, taking the fascia over the muscles and leaving nothing on the inner wall of the axilla except the posterior thoracic nerve, which should be preserved (Fig. 453). In this way the blood supply to a large portion of the tissues as well as the main lymphatic trunks along the axilla are controlled first, which is not done when the dissection is made from the sternum first instead of from the axilla.

The middle or long subscapular and the posterior thoracic nerves are preserved. The posterior thoracic, which supplies the serratus magnus, and the long subscapular, which supplies the latissimus dorsi, are important. They run along the walls of the axilla, and not through the axilla, so their preservation does not impair the efficiency of the operation so far as block dissection and curing cancer are concerned and at the same time conserves the usefulness of two large and important muscles. If these nerves are spared the movement of the shoulder joint will be but slightly if at all impaired.

After completing the dissection of the axilla the second skin incision is made by beginning about the middle of the initial incision, going around the breast, and ending below the ensiform cartilage about half way to the navel. The edge of this incision, distal to the tumor, is dissected up close to the skin, the incision being made in such a manner that it goes only through the deep layers of the skin. The subcutaneous tissue is undermined for several inches, keeping as close to the skin as possible (Fig. 454). In this way the subcutaneous tissue that has been shown by Handley to be very likely to con-

tain cancer cells is blocked out to be removed along with the mammary gland. This point is even more important than removing an unusual amount of the skin itself and with the extensive removal of the subcutaneous fat and fas-

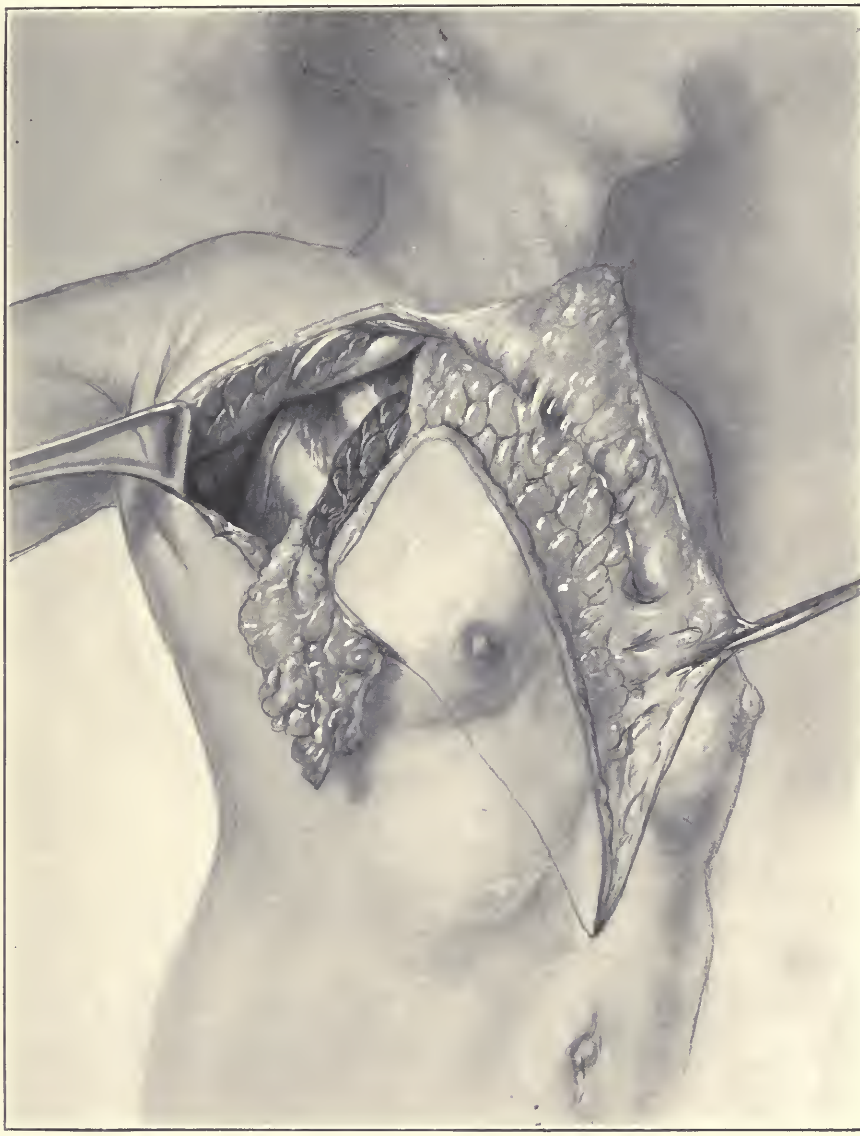

Fig. 454.—The incisions are extensively undermined in order to remove as much of the subcutaneous fat and fascia as possible. (Rodman.)

cia recurrences are probably fewer than where a somewhat more extensive removal of the skin is done without the undermining dissection for the subcutaneous tissue. Incidentally the undermining makes it easier to close the wound. This, however, is a minor consideration.

The third incision begins at the outer extremity of the initial incision as the second incision began about its middle. This is carried downward and inward and meets the second incision at an acute angle about half way between the ensiform cartilage and the umbilicus. This incision also is car-

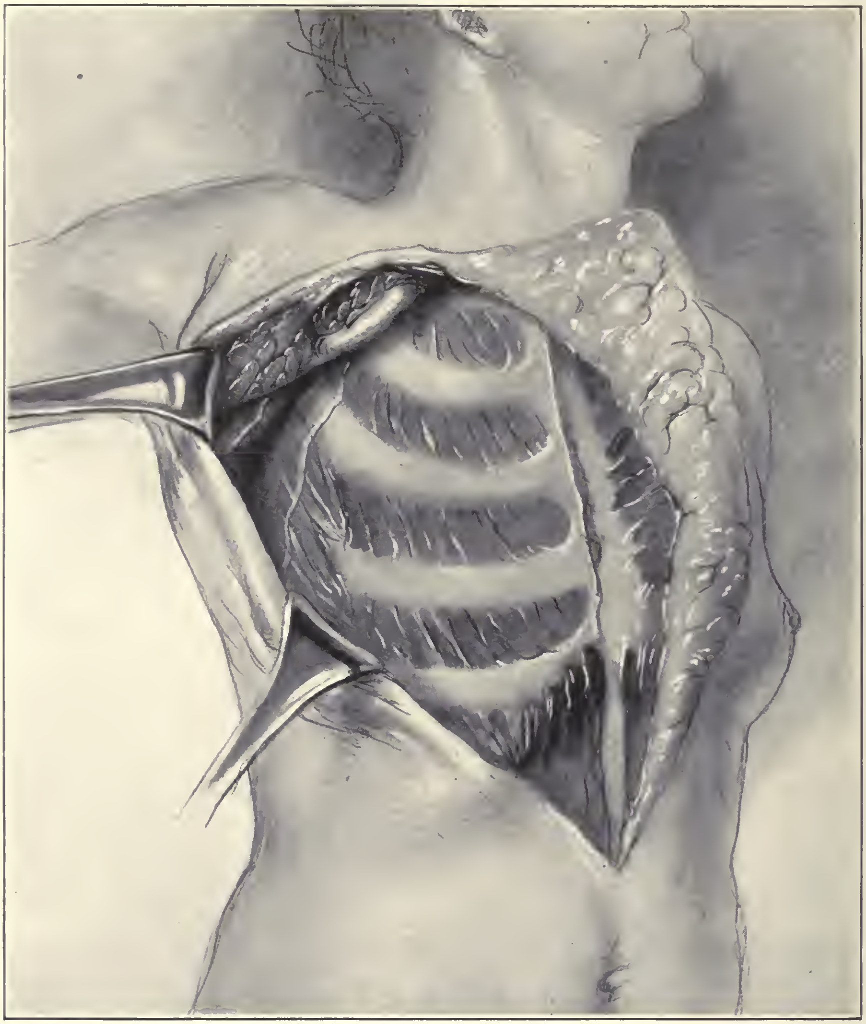

Fig. 455.—The breast with its covering of skin, the contents of the axilla, a portion of the sheath of the rectus muscles, and the adjoining fat and fascia have been removed in one mass. (Rodman.)

ried only through the skin, and the subcuticular tissue is carefully undermined and dissected from the skin for several inches, as along the second incision. The tissues are then removed from above downward, cutting the subcuticular tissue down to the deep fascia along the extremity of the undermined dissection, which should be at least three inches from the edge of the skin incision. This includes the fascia over the sternum. The or-

igin of the major pectoral muscle is severed and the perforating arteries are clamped. The fascia of the upper portion of the recti muscles and some of the fat between these muscles are included in the block dissection. The origin of the minor pectoral is severed close to the ribs while holding the muscle up with the finger to make it tense. The fascia along the edge of the serratus magnus is dissected to the outer limits of the undermined incision (Fig. 455). Care must be taken to include all fascia over the thorax and below the clavicle in this mass, as this fascia is particularly likely to harbor cancer cells.

The specimen is removed and should contain in one mass the mammary

Fig. 456.—Photograph of patient of the author on whom the Rodman operation was done, taken eleven months after the operation. Note the line of scar which shows that the incision was completely closed at the time of operation, and the mobility of the arm, which is unimpaired by the operation.

gland, with the cancer about the center of the excised skin, the pectoral muscles and the contents of the axilla attached to one end of the specimen, with a wide zone of subcutaneous fat and fascia surrounding the breast internally, above, and below, as well as the fascia over the upper portion of the recti muscles. The recti muscles should first be approximated by interrupted sutures of catgut and the clamped vessels are tied with catgut. The sutures of the skin begin at the lower angle and are interrupted silkwormgut. They are placed from below upward until the tension becomes great. Before sutures are placed over the axillary region a stab wound is made in the skin over the lower portion of the axilla and a rubber drainage tube is carried through the stab wound and fastened in position by suturing it to the skin. This

not only provides for drainage, but tends to produce a flow of lymph toward the tube and may in this way cause the washing out of cancer cells that might otherwise be absorbed. After the wound has been sutured about half way from below, suturing is begun at the upper angle, interrupted sutures of silkworm-gut being placed from this point down to the region of greatest tension. The sutures are introduced in such a manner as will provide for free movement of the shoulder and at the same time not produce too much tension. A fold of skin that runs backward can be sutured so as to relieve the tension. The principles of plastic surgery are utilized in closing this wound. It is wise never to have too fixed a rule for suturing such cases, as the amount of skin to be removed is regulated by the extent and location of the growth. At points of tension caused by the sutures short relaxation incisions are made, carrying the knife just through the skin and making the incision no longer than one-eighth or at most one-fourth of an inch. If this is done freely along the lines of tension, as shown by the appearance of white areas after the stitches are tied, venous drainage is promoted and there is but little likelihood of breaking down of the wound on account of lack of nutrition. It is well, however, to cover the wound with some sterile impervious material which may be left on for four days and will favor the nutrition of the skin along the suture line somewhat better than a simple dry dressing. If, however, the nutrition along the edges of the wound seems to be well established an ordinary dry dressing may be placed, taking care to reinforce the dressing along the exit of the tube. The tube is removed in five or six days (Fig. 456).

CHAPTER XXII

OPERATIONS FOR HERNIA

The emergency of hernia is due to strangulation, and this may occur with almost any type of hernia. The strangulation calls for immediate operation. After this is relieved the method of dealing with the bowel or omentum which was strangulated depends partly upon the condition of the imprisoned structures and partly upon the condition of the patient.

Strangulated inguinal hernia frequently occurs because of the great incidence of inguinal hernia, but proportionately the number of cases of strangulation of the femoral and umbilical hernias represents a higher percentage. The smaller the opening through which a hernia protrudes the greater the probability of strangulation, solely for mechanical reasons, whereas a large bulging hernia that may afford great discomfort is not likely to be strangulated unless there are bands or adhesions in the neck of the sac through which special loops are caught, or unless there are adhesions to a portion of the sac which fix the bowel at this point and predispose to a volvulus.

If the strangulation is in an inguinal or a femoral hernia an incision is made parallel with and just above Poupart's ligament. In an inguinal hernia, after dividing the skin and superficial fascia, the aponeurosis of the external oblique is split with scissors or with a knife on a grooved director. Blunt-pointed scissors are the most satisfactory instrument. The ring of constriction is divided by splitting it in an upward direction until the constriction is entirely relieved. The sac of a strangulated hernia is recognized by subperitoneal fat that is usually immediately over it, by its bluish color, and by the fact that it is thin and almost transparent and can be seen to glide over the contents beneath it. The sac should always be opened, but it is best first to divide the constriction. Sometimes, however, the tenseness of the sac from its contained bowel and fluid is so great that it is wiser to open the sac before attempting to relieve the constriction. If it is a direct inguinal hernia, care must be taken to avoid injuring the deep epigastric artery which lies to the outer side of the neck. In indirect hernia no such structure is present but a division of either type of hernia by carefully cutting down from without inward will make any vessel accessible, so its injury can either be avoided or the vessel can be readily clamped and tied.

In femoral hernia the so-called hernia knife or blunt-pointed bistoury is often used. The femoral canal cannot be freely divided without considerable danger of recurrence of the hernia. It is best in this type to make the same incision as in inguinal hernia and after retracting the lower margin of the wound to expose and free the sac. The abdomen is then opened and an ef-

fort is made at reduction, partly by manipulation of the sac and partly by pulling on the intestine through the abdominal incision. With this bimanual manipulation many femoral hernias can be reduced. If this procedure is of no avail the femoral ring can be nicked with a blunt-pointed bistoury or a knife carried down on a grooved director or by blunt scissors. The hernia knife may be inserted in the femoral canal from above after clearing Poupart's ligament and a cut is made inward in the direction of the fibers of the ligament. The opening is then more readily repaired than if the canal were cut upward across Poupart's ligament.

In umbilical hernia the same general principles apply. The division of the constricting ring should be outward so that the margins of the ring can be overlapped from above downward.

In acquired incisional or ventral hernia following either accident or operation strangulation is not a frequent occurrence, though on account of adhesions obstruction of the bowel may occur.

After reduction of the contents of a strangulated hernial sac the bowel should always be inspected. If there is a suspicion of gangrene and no perforation of the bowel, it is best to return the suspicious loop to the abdominal cavity just beneath the incision for a few minutes. Then the loop is inspected and if the color has improved and it seems that the loop will recover, the hernia is treated according to the indications, and the bowel is further disregarded. If the bowel appears gangrenous, or if there is a suspicion of perforation, the bowel should not be returned to the abdominal cavity, but is surrounded for five minutes to ten minutes with gauze wrung out of hot salt solution, or if the condition of the patient permits, until it is apparent what will be the effect of the strangulation on the bowel. Often when a loop looks even doubtful of recovery, it will clear up after such treatment. If the bowel is frankly gangrenous or threatens to perforate and, of course, if a perforation has actually occurred, the surrounding tissues and the peritoneal cavity are protected by being packed off with moist gauze and the bowel is resected. The technic of resection is described in the chapter on Intestinal Surgery. A careful resection is made, with attention to closure of the mesenteric triangles of the bowel before opening the intestine and severing it from the mesenteric border outward. Union can be rapidly made with a needle and thread. This operation can be done under a local anesthetic. Resection is usually preferable to a large fecal fistula. If the strangulation has existed for sometime and if the bowel on the proximal side of the strangulation is considerably dilated, an enterostomy by the method that is described in the chapter on Intestinal Surgery, in which the principle of Coffey is employed, affords the greatest safety. This may be done with or without a resection. If there is considerable distention of the bowel and resection is done an enterostomy should always be performed, using a rubber catheter, making a valve enterostomy, and bringing the tube through a stab wound either before it is inserted into the enterostomy opening, or else clamping it near the bowel and then bringing it out through a stab wound. In this way

infection of the tissues from the fecal contents is avoided. If a large loop of bowel is strangulated and dilated and if the condition of the bowel is doubtful after waiting several minutes, the course to be pursued depends upon the ability of the surgeon and the condition of the patient. If the surgeon has had some experience, and particularly experience in animal experimentation, and has mastered the technic of resection, it is probably safer for the patient if resection is done. If, however, the surgeon is doubtful of his technic and has had little or no experience in resecting bowel, it would be safer to return the doubtful loop and let the patient take his chances. In frank gangrene, of course, resection should always be done.

Whether the radical cure of a hernia should be undertaken after the relief of the strangulation depends largely upon the condition of the patient. It should always be attempted unless there is strong contraindication. Where the bowel has already ruptured and the tissues have become infected no serious attempt at radical cure should be made, but a few sutures are placed to retain the contents of the abdomen and the wound is abundantly drained, being packed loosely with gauze. Later, when the infection has been fully overcome, an operation for radical cure can be done.

INGUINAL HERNIA

A type of hernia that is frequently incarcerated, but not often strangulated, is "sliding" hernia. This occurs most frequently on the left side, but may be found on the right side. It is possible to have a sliding hernia of large bowel with a loop of small bowel strangulated in the sac. The pathology of sliding hernia must be understood in order to operate upon it intelligently. It has been variously explained as a condition in which the large bowel, particularly the sigmoid, slides down between the two layers of its mesentery and appears in such a manner that the wall of the bowel itself forms part of the sac. This condition has been very satisfactorily explained by Louis Ransohoff, of Cincinnati, as merely a fusion and disappearance of the peritoneal coats. This is quite common in embryologic development, and is often seen when portions of the ascending or descending colon are so closely attached to the abdominal wall by the fusion of the peritoneum that they are practically as much extraperitoneal organs as the kidneys. Sliding hernia is particularly prone to recur and should be carefully reduced after freeing the attachments of the bowel through the ring and into the abdominal cavity. In many instances the portion of the sac that is left can be utilized to cover the raw surface of the sliding bowel as a flap somewhat similar to the method used in the "bottle" operation for hydrocele. The relation of the peritoneum of the sac to a sliding hernia is quite similar to that of the tunica vaginalis to the testicle.

The radical cure of inguinal hernia has an interesting history. The operation of Bassini has stood the test of time and has proved satisfactory in most cases of inguinal hernia. The only modification of Bassini's technic

that appears as a marked improvement is the substitution of the absorbable suture for the nonabsorbable silk that was originally used by Bassini. While fine silk sutures can be employed without the probability of trouble resulting, in operations on hernia stouter material must be used and the larger nonabsorbable sutures are likely to irritate the tissues and an effort to extrude them often follows.

The principle of the Bassini operation is to reconstruct the inguinal canal by suturing the conjoined tendon and the internal oblique and transversalis muscles to the shelving edge of Poupart's ligament beneath the spermatic cord, while the aponeurosis of the external oblique is brought together over the cord. An incision is made over the inguinal canal parallel to Poupart's ligament and about half an inch above it and extending from over the external inguinal ring to an inch beyond the region of the internal ring (Fig. 457). If the operation is done under a local anesthetic, which

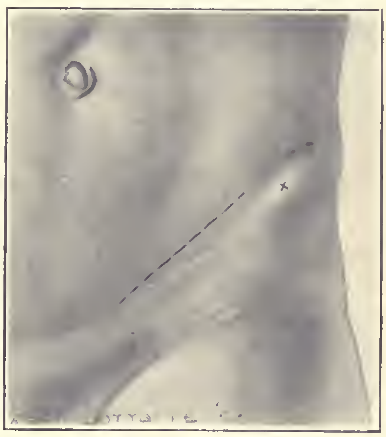

Fig. 457.—Line of incision for exposure of the inguinal canal in the Bassini operation for inguinal hernia.

can often be satisfactorily used, the incision should extend slightly farther outward than under a general anesthetic, as it is necessary to infiltrate the ilioinguinal and the iliohypogastric nerves in an early stage of the operation. Here the fibers that lie about the center of the inguinal canal are identified by the bulging and the thinning out of the fibers and by their position in regard to the external ring and are split with a knife at the outer end of the incision (Fig. 458). The edges of the split fibers are seized with hemostatic forceps and gently elevated, while the tissues beneath are separated until the ilioinguinal and iliohypogastric nerves are identified. Occasionally one or the other of these nerves is absent and not infrequently one is much larger than the other one. Their course and position is somewhat variable, but they can usually be found beneath the split portion of the aponeurosis of the external oblique about two or three inches from the external ring (Fig. 459). These nerves are infiltrated with novocain solution through a fine hypodermic needle if the operation is done

under local anesthesia, and the fibers of the aponeurosis are split down through the external ring. In operating under a general anesthetic the aponeurosis is usually split from the external ring upward. This method is quicker and somewhat easier, but not infrequently these two nerves are injured when the aponeurosis is cut in this way and this results in areas of anesthesia and hyperesthesia which are somewhat annoying to the patient. Whether a general anesthetic or a local anesthetic is used an effort should be made not only to preserve these nerves but to avoid their being included in the sutures that approximate the structures beneath the cord.

The edges of the split aponeurosis are separated from the adjacent tis-

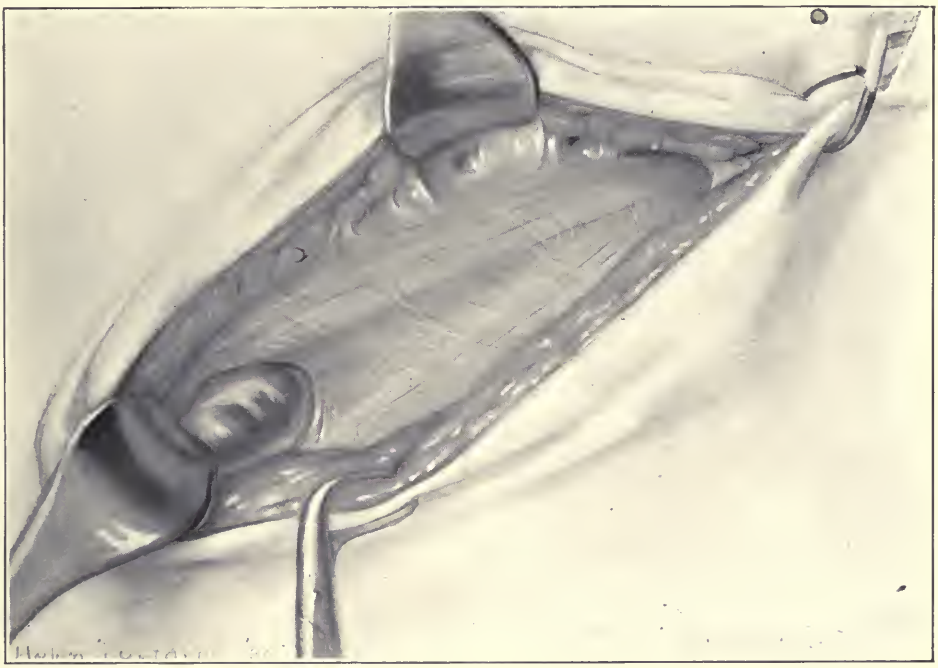

Fig. 458.—The external inguinal ring is exposed.

sue below and above, and the nerves are kept under observation to prevent injury. The iliohypogastric penetrates the aponeurosis of the external oblique toward the inner and upper portion of the wound, usually about an inch from the margin of the split aponeurosis. Unless it is kept under observation it may readily be bruised or torn where it enters this structure.

After laying open the roof of the inguinal canal by splitting the fibers of the aponeurosis of the external oblique, the procedure of Bassini is the same whether a local or a general anesthetic is employed. To avoid pain particular care must be used in infiltrating the structures around the internal inguinal ring and around the neck of the sac.

The cremaster muscle and a layer of transversalis fascia which cover the cord and the sac are divided, and the cord and the sac are identified.

The structures beneath the cord are incised while the cord and sac are lifted up, taking care to make the incision in a bloodless area. These structures are further divided with scissors so that the cord and sac together are separated from the inguinal canal, except at the internal ring. A piece of gauze is carried beneath the cord and sac. The sac is identified and dissected free from the cord. This is usually best done by incising it and stripping it away from the tissues while the finger is inserted to identify and stabilize it (Fig. 460). Often the structures over the incised sac can be seized with hemostatic forceps and pulled away, or else they can be brushed away with

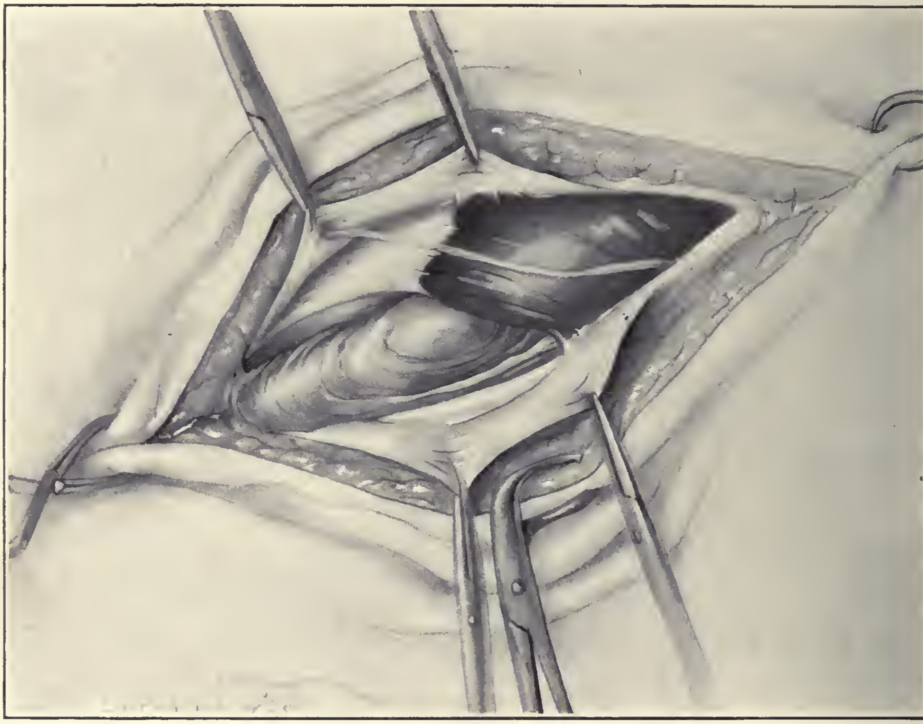

Fig. 459.—The inguinal canal is exposed by splitting the fibers of the external oblique. Note the ilio-hypogastric nerve, which should be protected.

dry gauze. It is dissected free from all structures well up into the abdomen and made tense by traction while a ligature of tanned or chromic catgut in a needle transfixes its neck as high up as possible. The ligature is tied by an assistant while the surgeon holds his finger in the sac down to the ligature to prevent a knuckle of bowel or a piece of omentum being caught in the ligature (Fig. 461). The sac is cut away half an inch from the ligature and the ligature is cut short when the neck of the sac, if it has been properly dissected from the surrounding tissues, will retract within the abdomen behind the cord and practically out of sight. (Fig. 462.) Four or five interrupted sutures of tanned or chromic catgut or kangaroo tendon approximate the internal oblique and transversalis muscles and the

conjoined tendon above to the shelving edge of Poupart's ligament below. The sutures are inserted from above downward, care being taken to avoid the inclusion within the sutures of the ilioinguinal or the iliohypogastric nerves. The first suture is placed close to the cord as it emerges from the internal inguinal ring. This suture is inserted while the cord is so held that the portion emerging from the ring is perpendicular to the body. The suture catches a good bite of the internal oblique and transversalis muscle in such a way that when carried across to the shelving edges of Poupart's ligament, the suture is snugly in contact with the cord. In this way just enough play is

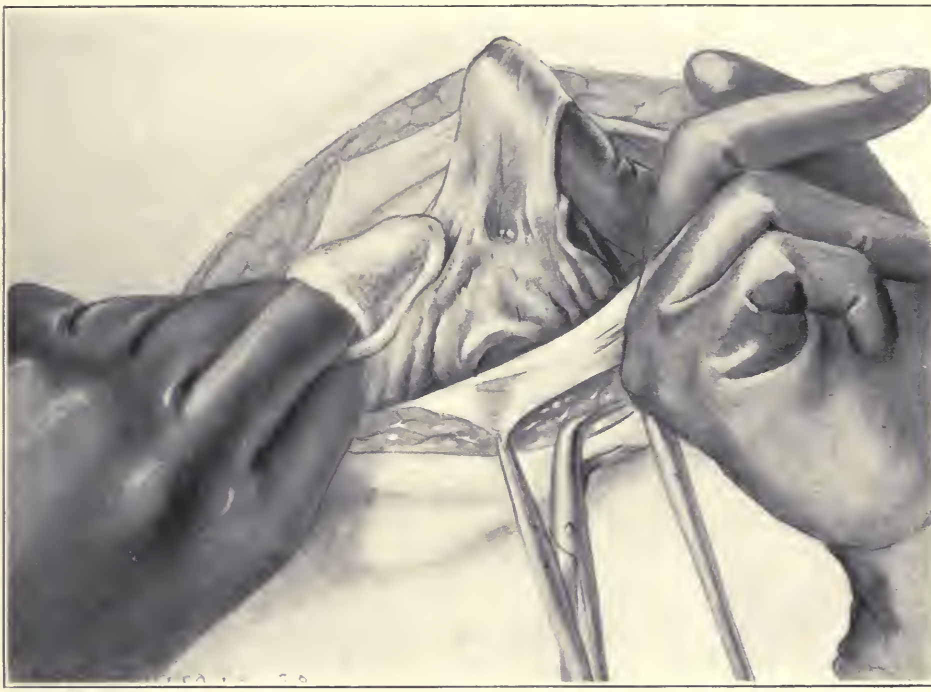

Fig. 460.—The sac is being freed.

left for the emergence of the cord through the internal ring without constricting it too greatly. This suture is tied just tightly enough to secure satisfactory approximation. It is best to tie three knots. If tied too tightly necrosis results and there may be recurrence of the hernia. If not tied sufficiently tightly the union will not be firm. Three or four sutures are placed below this at intervals of about one-half an inch. The last suture of this row catches in addition to the conjoined tendon a small bite in the under surface of the aponeurosis of the external oblique as it is reflected inward by retraction (Fig. 463). Care must again be observed to avoid the iliohypogastric nerve which enters the aponeurosis of the external oblique near this point. This suture, which like the others that have been inserted, is carried under the cord, catches the edge of Poupart's ligament near the pubic spine. Coley

has called attention to the advisability of inserting this last suture in the manner described, as it adds materially to the strength of the abdominal wall in this region. Coley also places one or two sutures external to the internal ring, uniting the internal oblique to Poupart's ligament.

The cord is allowed to lie upon this row of sutures and the aponeurosis of the external oblique, which was split at an early stage in the operation, is united by a continuous lock stitch of tanned catgut (Fig. 464). The vessels which have been clamped are tied and the skin wound is united in the usual manner. I have found that a continuous mattress suture of fine tanned

Fig. 461.—The neck of the sac is ligated.

catgut is very satisfactory for suturing the skin in this region (Fig. 465). The wound is dressed with an abundance of gauze and cotton and a firm spica bandage is applied. This operation is an exceedingly satisfactory one and in indirect inguinal hernia will, if properly carried out, result in the permanent cure of more than ninety-five per cent of the patients.

In some instances, particularly when a local anesthetic is used, the type of operation that has been described by Ferguson or by Andrews is easier and gives satisfaction, though the results in indirect hernia are not superior to those obtained by the Bassini operation and in direct hernia the results are not so good.

In dissection around the sac very frequently a considerable deposit of

fat is found. This fat sometimes is so marked and so circumscribed as to be practically a lipoma and it may extend from the properitoneal fat along the cord or from between the abdominal muscles. It is possible that such deposits have an etiologic relation to the hernia. At any rate they should be dissected free so that the cord can be closed in snugly at the internal ring. Many operators follow the suggestion of Coley and place a suture external to the cord as well as one below it so that the cord emerges between the two sutures. If there seems to be a marked deficiency in the origin of the internal oblique and transversalis muscle in Poupart's ligament, as Ferguson has noted, sutures to correct this deficiency must always be placed. The testicles are sup-

Fig. 462.—The cord is mobilized.

ported by a broad strip of adhesive which runs from one thigh to another and permits the testicles to lie on this adhesive as on a shelf.

The operation of E. Wyllys Andrews involves the principle of imbrication and in indirect hernia with a strong conjoined tendon the method is very satisfactory. It is also desirable in operations under local anesthesia, for it avoids handling the cord and dissection of the structures beneath the cord which sometimes even after blocking the ilioinguinal and iliohypogastric nerves cause some discomfort. In the Andrews operation the incision is made similar to the Bassini operation, that is, half an inch above and parallel to Poupart's ligament and extending four or five inches outward from the external inguinal ring. The external oblique is split from above downward

as though the operation were to be done under local anesthesia. This is an excellent rule in any hernia operation. After splitting the fibers of the aponeurosis of the external oblique through the external ring, the aponeurosis is dissected up on each side until Poupart's ligament is well exposed below and the conjoined tendon and about one and a half inches of the internal oblique and transversalis muscles are uncovered under the upper portion of the wound. No veins, fascia or portions of the cremaster muscle are removed. The sac is freed and excised as in the Bassini operation. If the sac is large the part that lies in the scrotum is not always removed, but that portion in the inguinal canal is resected. In a large hernia when the sac is completely dissected Andrews sometimes folds up the sac

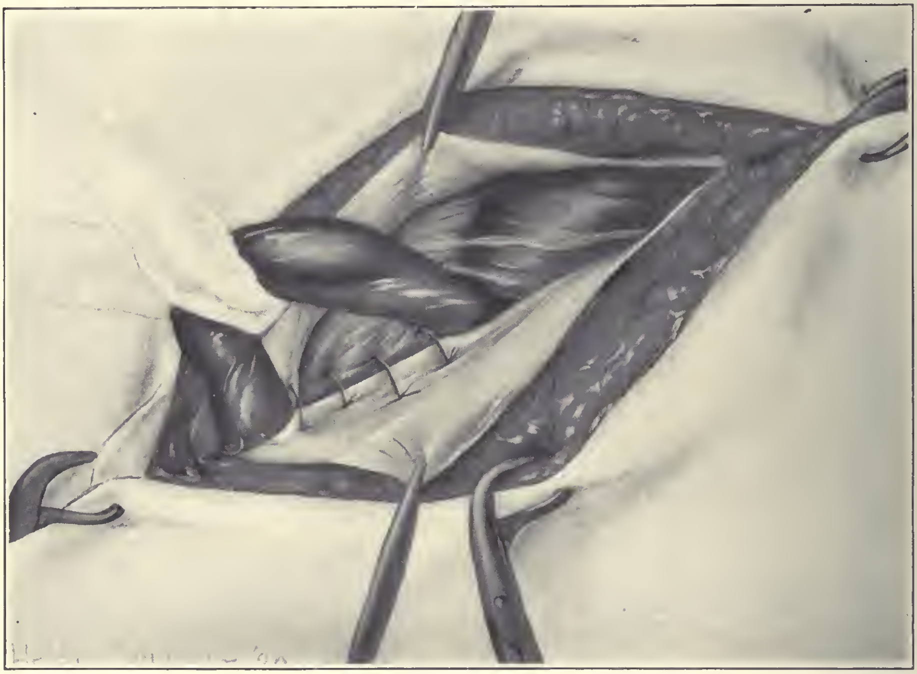

Fig. 463.—The conjoined tendon and the internal oblique and transversalis muscles are sutured to Poupart's ligament beneath the cord. Note that the inner suture catches in addition a portion of the under surface of the aponeurosis of the external oblique.

by suturing it according to the method of Macewen. From two to five sutures of chromic catgut unite the conjoined tendon and the internal oblique and transversalis muscles, together with the edge of the aponeurosis of the external oblique just above them, to the shelving edge of Poupart's ligament over the cord. This leaves a flap consisting of the outer portion of the aponeurosis of the external oblique which has been previously split. This flap is then folded over the row of sutures and fastened to the aponeurosis of the external oblique by a continuous lock stitch of chromic or tanned catgut. Andrews finds that in direct hernias the overlapping should be done by placing the first row of sutures beneath the cord so the sutures unite the conjoined ten-

don and the upper edge of the split aponeurosis of the external oblique to the shelving edge of Poupart's ligament beneath the cord. The lower flap of the aponeurosis is then folded over the cord and fastened in such a manner that the cord lies in a new canal. The skin is closed in the usual way. This operation has much to commend it in small indirect hernias that are done under local anesthesia, but it is sometimes followed, particularly in muscular individuals, by a sensation of drawing or tightening that may last for months after the operation.

In any operation involving the transplantation of the cord, as in the Bassini operation, the cremaster muscle which is intimately associated with the

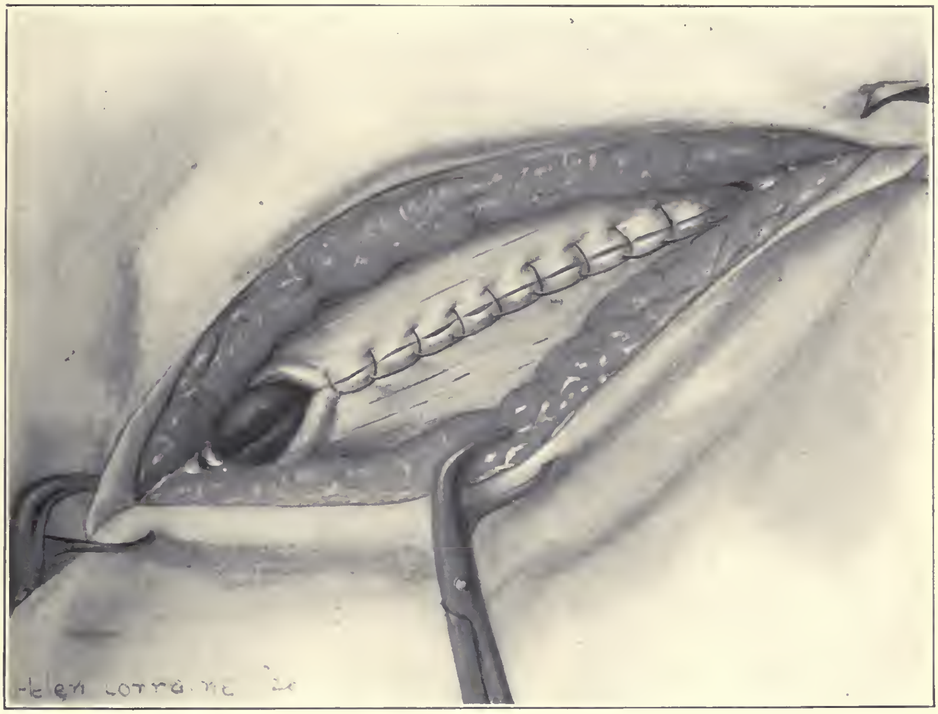

Fig. 464.—The incision in the aponeurosis of the external oblique is closed with a continuous lock stitch.

transversalis fascia should be preserved by splitting it for the whole length of the cord from the internal to the external ring and shoving it behind the cord. In this way it will lie behind the internal row of sutures and act as a slight support against the intraabdominal pressure.

Ferguson has found that many recurrences are due to a deficient origin of the internal oblique and transversalis muscles from the outer portion of Poupart's ligament. Consequently, after the sac had been removed in the usual way, he united the transversalis fascia by a continuous suture and then sutured the internal oblique and transversalis to Poupart's ligament from the outer portion of the wound down to the inner portion, merely leaving a sufficient opening at the external ring for the cord. The split edges of

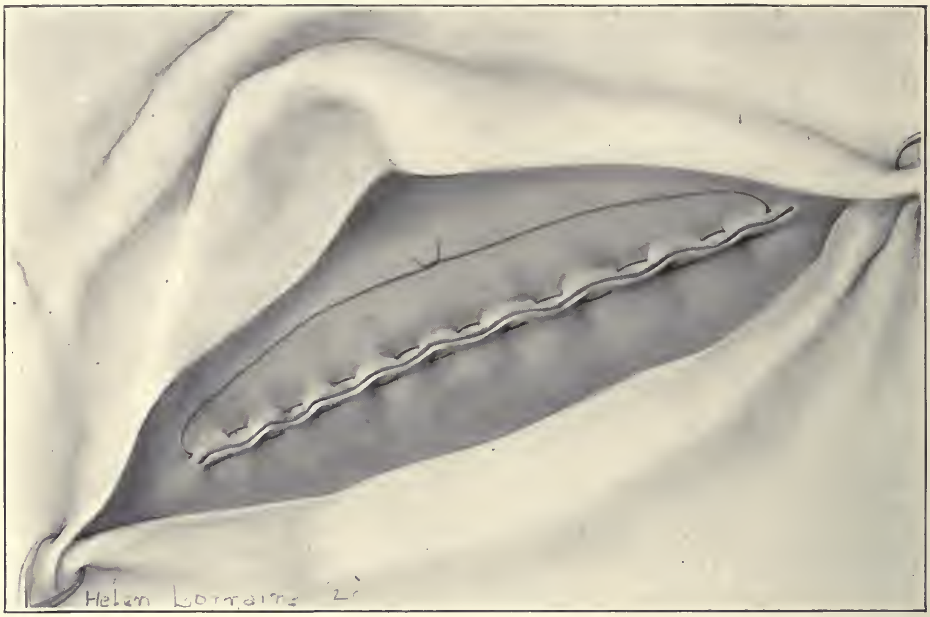

Fig. 465.—The skin is closed with a continuous mattress suture of fine tanned catgut.

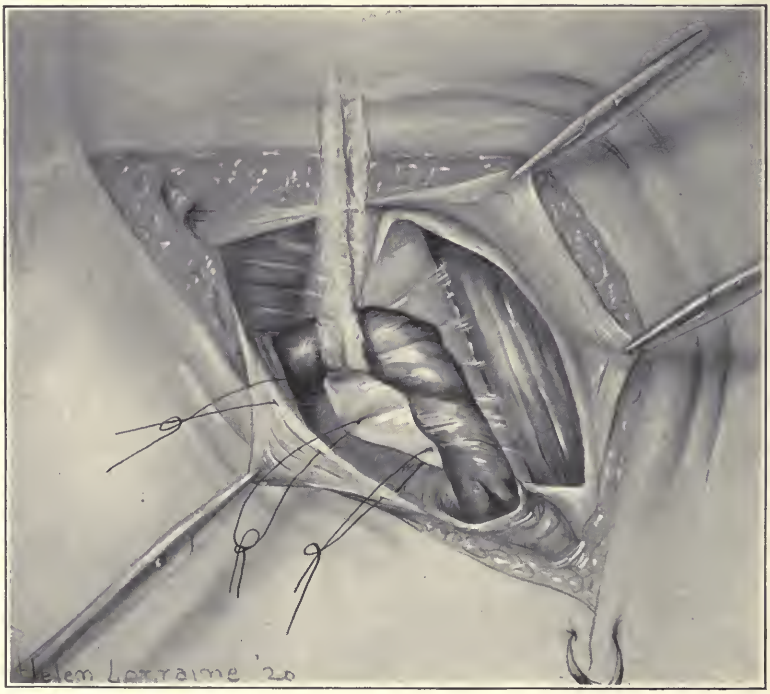

Fig. 466.—A flap is formed from the sheath of the rectus muscle, according to the method of Halsted, as an additional support in direct inguinal hernia.

the aponeurosis of the external oblique are united in the usual way. The cord is not disturbed, but merely pushed down. Ferguson recommended a curved incision, which seems unnecessary.

The most unsatisfactory type of inguinal hernia to deal with is a direct hernia or else a combined direct and indirect in which there is a double sac, one protruding to the inner and the other to the outer side of the deep epigastric vessels. The difficulty in curing a direct inguinal hernia is because this hernia is due to a defect in the conjoined tendon. This defect may consist in an abnormally weak conjoined tendon or the tendon may be apparently entirely lacking, and there is nothing to support this weak re-

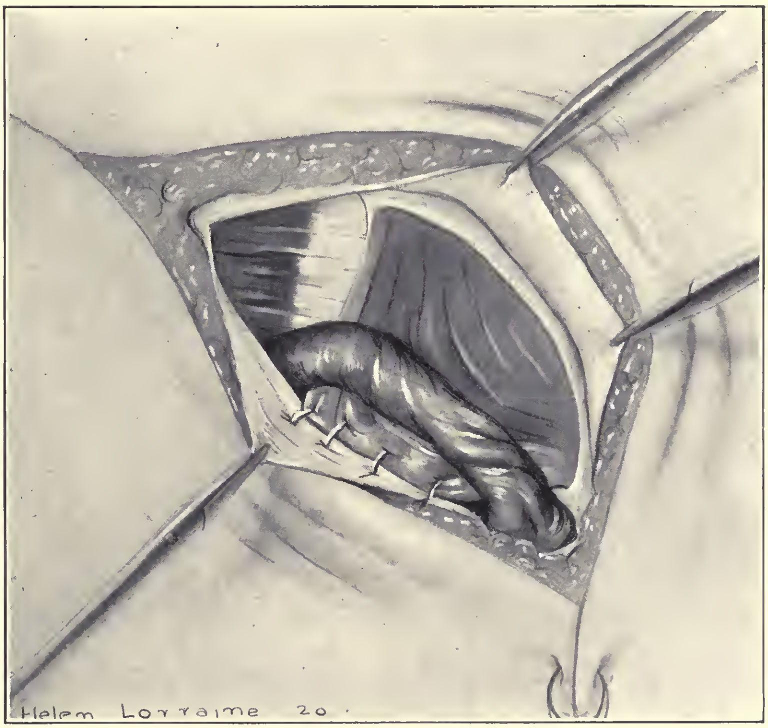

Fig. 467.—In addition to the flap from the sheath of the rectus muscle, the fibers of the rectus muscle can also be transplanted according to the suggestion of Bloodgood.

gion in the inguinal canal, whereas in indirect hernia with a strong conjoined tendon that is almost normally inserted the inner part of the wound can be readily fortified. Several suggestions have been made concerning the best method of strengthening this weak spot in the inguinal canal. Bloodgood has practiced transplantation of the rectus muscle by splitting the sheath of the rectus and suturing the muscle instead of the conjoined tendon to Poupart's ligament. Halsted makes a flap of fascia from the sheath of the rectus with the base or hinge outward. This flap is sutured under the cord, replacing the conjoined tendon (Fig. 466). In addition to this flap the rectus muscle can also be sutured to Poupart's ligament, which makes

a double reinforcement (Fig. 467). It has been objected that the rectus muscle alone will not hold satisfactorily but by splitting its sheath, forming a flap, and suturing this under the cord, and then suturing the rectus muscle under the cord just over the flap, the rectus will be more likely to maintain its position. Even if it does not, the fascia formed from the flap of the rectus sheath will probably be sufficient reinforcement. In direct hernia and in indirect hernia in which the conjoined tendon appears weak, this modification should be done. In direct hernia it is important to suture the transversalis fascia together over the stump of the sac.

There are a number of different operations for hernia. The most satis-

Fig. 468.—Exposure of the neck of the sac from within the peritoneal cavity. (Method of G. P. LaRoque.)

Fig. 469.—Suturing the neck of the sac from within the peritoneal cavity. (LaRoque.)

factory operation in my hands has been the operation of Bassini, as has been described, combined with the Halsted-Bloodgood modification of transplantation of a flap from the sheath of the rectus muscle and of the rectus muscle itself where the conjoined tendon is very weak. In cases where the internal ring is the only structure at fault and where a local anesthetic is to be used, the Andrews or Ferguson operation is very satisfactory, but the Bassini with some modification can be used in almost every form of inguinal hernia, either direct or indirect, with excellent results. In any type of operation the cord should be handled gently and no veins or other structures except fat should be removed from the cord.

The treatment of the sac of either inguinal or femoral hernia is an important step in the operation. It has been objected that tying the sac at its neck will leave a dimple within the peritoneal cavity, which invites a recurrence of the hernia. To obviate this it is always necessary to dissect the sac well up beneath the abdominal muscles, to make moderate traction upon it, and to place the ligature flush with the level of the external portion of the peritoneal surface. Preferably the ligature should transfix the neck of the sac. This method of ligating is important in any type of operation for hernia. Even such a ligature, however, has been objected to because in sacs with large necks a dimple may still be left. The Macewen method has apparent advantages, but they are more apparent than real. The technic of Macewen's treatment of the sac is as follows: After partly freeing the sac from the cord the surgeon introduces his finger into the inguinal canal and bluntly dissects the sac from the cord and from the walls of the inguinal canal and the surrounding tissues. He then carries his finger through the internal ring, separating the peritoneum from the abdominal wall for an inch around the internal ring. A chromic or tanned catgut suture is introduced at the lowest portion of the sac and quilted through the sac several times toward its neck so that pulling upon the suture will draw the sac up into a lump. The needle with the end of the suture that has come out at the neck of the sac is then carried through the internal ring and transfixes the abdominal muscles an inch above the internal ring, while the skin is retracted to avoid puncturing it. The suture is pulled snugly and folds up the sac under the abdominal muscles so that it lies between the peritoneum and the inner surface of the abdominal muscles. This suture is permanently anchored, whipping it several times through the external oblique. Formerly this method of treating the sac was considerably in vogue, but it does not of necessity avoid the dimpling that has been objected to and it may form an uneven surface at a naturally well protected point which will increase the force of the intraabdominal pressure further down on the inguinal canal. In a sac with a very broad neck a satisfactory treatment is to close the neck of the sac flush with the peritoneum with a continuous purse-string suture, just as though an incision had been made through the peritoneum in performing an abdominal section. The treatment of the sac cannot be entirely standardized by one method, because the character and shape of the sac may alter greatly.

LaRoque,[1] of Richmond, has presented the problem of treating the sac of either inguinal or femoral hernias in an excellent manner. When it is difficult to excise the sac and when it is thin and small he incises the peritoneum above the neck of the sac, either by strongly retracting the internal oblique and transversalis muscles, or by splitting these muscles in the direction of their fibers. The internal opening of the sac is exposed by traction upon the lower margin of the peritoneal wound with a hemostatic forceps, together with retraction of the upper margin (Fig. 468). The orifice

[1]Surg., Gynec. & Obst., Nov., 1919, p. 507, et seq.

Fig. 470.—Method of inverting a large sac from within the peritoneal cavity. (LaRoque.)

Fig. 471.—Suturing the neck of a large sac from within the peritoneal cavity. (LaRoque.)

of the sac is then whipped over with a continuous catgut suture and the redundant peritoneum is folded over the sutured orifice and takes up the slack in the peritoneum in this region, preventing the formation of a dimple (Fig. 469). Where the sac is large, however, and presents too bulky a mass to be enclosed along with the cord, the finger is inserted into it from the peritoneal opening and it is freed from the spermatic cord and the surrounding structures. The finger is then withdrawn and a hemostatic or pedicle forceps is introduced through the neck of the sac to its lowest portion which is caught and pulled up, turning it inside out (Fig. 470). It can then be treated by suturing the upper margin of the wound in the peritoneum to the base of the everted sac, after bringing it up through the peritoneal wound (Fig. 471). By placing the sutures an inch or more beyond the neck of the sac all redundant peritoneum in the neighborhood of the neck is put on a stretch and the peritoneal opening of the internal ring is completely obliterated. The transversalis fascia which is inverted with the sac is included in the peritoneal suturing. This makes most of the sac extraperitoneal. A ligature is then placed around it if it is large and the excess is amputated. If the sac is small it is not necessary to excise it. In either event if the muscles are split they are sutured over the sac or its stump and the rest of the hernia operation is done according to some of the technics that have already been described.

FEMORAL HERNIA

Femoral hernia occurs through the femoral canal and is most frequently found in women. It is peculiarly liable to strangulation because of the comparatively small caliber and the rigidity of the femoral canal. A number of rather complicated operations has been devised though the simpler methods appear to be quite satisfactory. In the radical cure of a nonstrangulated femoral hernia high excision of the sac together with obliteration of the femoral canal as has been practiced by a number of operators, particularly by Coley, seems to give excellent results.

The incision for operation on femoral hernia is similar to that for inguinal hernia, though it is made closer to Poupart's ligament, being parallel to Poupart's ligament and just above it. The aponeurosis of the external oblique is exposed and the lower margin of the wound retracted to uncover the sac. Some operators prefer a vertical incision, beginning about an inch above Poupart's ligament and going downward on the thigh. This is objectionable because it leaves a scar that runs transversely to the creases in the groin and may cause discomfort. Then, too, when ligation of the sac high up in the femoral canal is difficult the peritoneum can be opened and the sac inverted according to the method of LaRoque.

After exposing the neck of the sac its body is separated from the surrounding tissues. The sac of a femoral hernia is always thickly covered with fat, which is uncommon in inguinal hernia, except in direct in-

guinal hernia where the sac is near the bladder. The sac of a femoral hernia is usually easily separated from the surrounding tissue. Its neck, together with the attached fat, is dissected well up into the femoral canal while the roof of the femoral canal is strongly retracted with a small blunt retractor. The sac is opened and inspected. If there is adherent omentum the adhesions are separated and the bleeding parts of the omentum are ligated with catgut and the omentum is returned. If the omentum is thick and contains much scar tissue it should be pulled down until healthy omentum is reached and at this point is ligated in small sections and the distal portion removed. It is best to protect the raw surface of the omentum by whipping over it the adjoining healthy omentum. Sometimes, however, this may make too large a bulk to permit reduction of the mass through the femoral canal. To facilitate reduction it may be necessary to ligate and divide the omentum at different levels, but care must be taken to see that there is no severed vessel between the ligatures. The omentum should never be returned to the peritoneal cavity until it is certain that bleeding from the stump has been entirely and satisfactorily controlled.

Having dealt with the contents of the sac if there are any, the neck is transfixed with tanned or chromic catgut in a needle, firmly tied, and the sac is cut away, leaving a stump about one-third of an inch long so there will be no possibility of the ligature slipping. The stump should then retract well within the femoral canal. It is important to see that the neck of the sac is thoroughly separated high up into the femoral canal before it is ligated and if this is done the stump will retract so it will be practically out of sight. The femoral canal is obliterated by a suture of tanned or chromic catgut in a curved needle. This begins over the inner portion of the roof of the femoral canal through Poupart's ligament. The margin of the femoral canal is strongly retracted upward by a small blunt retractor and a second bite is taken in the pectineus muscle and the fascia along the inner portion of the floor of the femoral canal. This is near the origin of the muscle from the pubic bone. The suture is then carried to the outer wall of the femoral canal and a bite is taken in the tissues and fascia in this neighborhood, taking care not to injure the femoral vein. Catching a small piece of the fascia to the inner side of the sheath of the femoral vein affords a strong hold. The needle is then carried through the roof of the femoral canal, penetrating Poupart's ligament, but at a point lower down than the beginning of the suture so that a sufficient amount of the fibers of Poupart's ligament lies between the levels of the beginning and the ending of the suture in order not to split Poupart's ligament. The suture when snugly tied obliterates the femoral canal. The skin is closed in the usual manner. A dressing with a spica bandage is applied to maintain firm pressure on the wound and to prevent an accumulation of serum in the space from which the sac was dissected.

The so-called sliding hernia has been mentioned. It often occurs in femoral hernia. The portion of the intestine uncovered with peritoneum which was

formerly thought to be a sliding or eversion of the mesentery, but is now known to be only an obliteration of the peritoneum, is always on the outer side of the sac. The sac should be carefully dissected on all sides, except where it is attached to the large bowel. The sac is split at the farthest point from the large bowel, reflected over that portion of bowel which is uncovered by peritoneum, and held in position by a few sutures. The vessels of the bowel are carefully protected in order not to impair its nutrition.

An operation for femoral hernia by attacking the sac from above has been proposed by Dujarier and also by M. G. Seelig and Tuholski. This

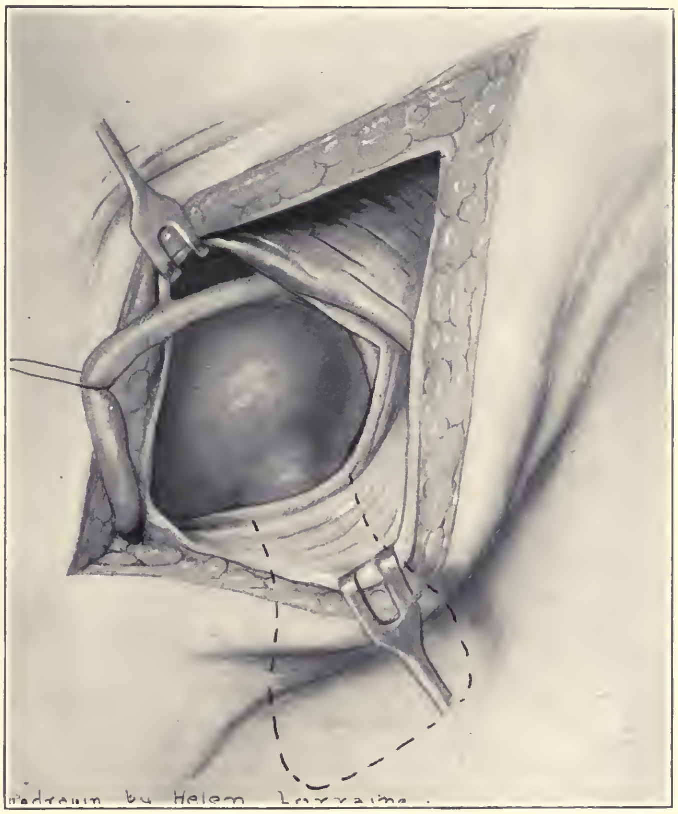

Fig. 472.—Exposure of neck of the sac of a femoral hernia by the method of Seelig and Tuholski.

method has many obvious advantages and should always be used in strangulated or incarcerated femoral hernia. It is sometimes difficult in a strangulated hernia to be certain whether the hernia is femoral or inguinal and the incision for femoral hernia should under all conditions be parallel to Poupart's ligament and only slightly lower than the incision for inguinal hernia. The incision extends downward and inward somewhat nearer the pubis than in inguinal hernia,[2] and is about four inches in length. The aponeurosis of the

[2]Seelig & Tuholski: Surg., Gynec. & Obst., Jan., 1914, p. 55, et seq.

external oblique is divided along the direction of its fibers as in inguinal hernia, and the upper flap of the aponeurosis together with the conjoined tendon is retracted upward while the lower flap is retracted downward to expose the inner surface of Poupart's ligament. A strip of gauze or tape may be placed under the round ligament or under the spermatic cord to retract it out of the way. This exposes the transversalis fascia which is very thin and beneath this is the peritoneum (Fig. 472). The deep epigastric artery is retracted externally or it may be doubly ligated and divided. The

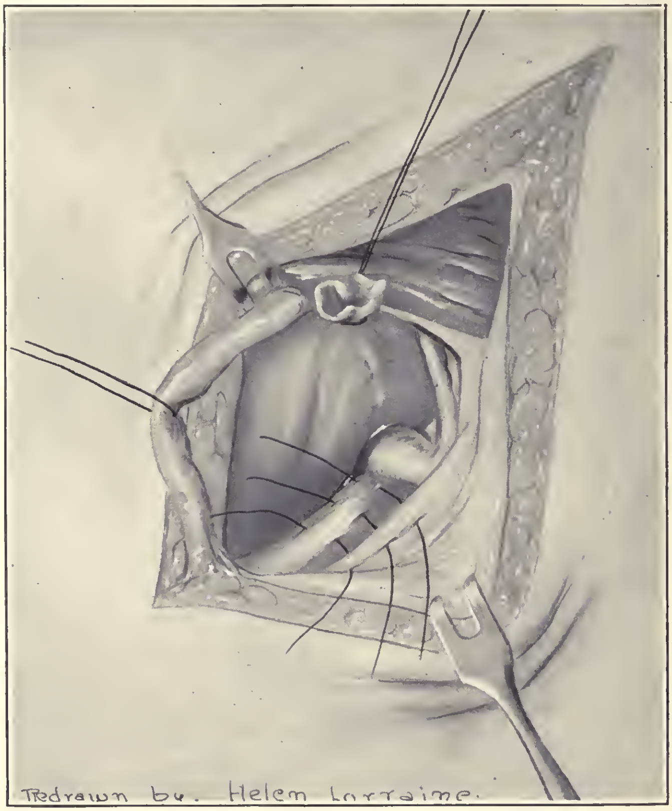

Fig. 473.—The neck of the sac is ligated, the sac excised, and sutures are placed to obliterate the femoral canal. (Seelig and Tuholski.)

transversalis fascia is divided and caught in retractors and the peritoneum near the neck of the hernial sac is brought into view. The peritoneum is opened just above the neck of the sac and the hernial contents are pulled out of the sac. This may be aided by pressure over the sac with one hand while the contents are being pulled upon with the fingers of the other hand within the abdomen. If there is strangulation the constriction is overcome by cutting the inner margin of the femoral ring, which constitutes Gimbernat's ligament. This is much more easily repaired than the usual method of cutting forward which divides transversely the important fibers of Poupart's

ligament and makes subsequent repair difficult. This incision is made with blunt-pointed scissors or a probe-pointed knife. Any vessel that is injured can be readily exposed and clamped. If the hernial contents are adherent to the sac, sometimes with traction the hernial contents together with the sac, can be delivered into the abdomen through the wound, the sac being inverted. The adhesions are readily dealt with. If the sac is adherent and cannot be delivered in this manner an incision may be made directly over it, though, as a rule, retraction of the skin and subcutaneous fat of the lower margin of the wound will enable the sac to be dealt with without the additional incision. If the hernial contents have been reduced, a pair of hemostatic forceps is inserted through the abdominal wound into the sac to its bottom, which it seizes and inverts. The sac is closed by a transfixion ligature of catgut in such a manner that the stump leaves no dimple (Fig. 473). It is also possible to treat the sac as recommended by LaRoque in inguinal hernia. The femoral ring is easily closed as it is fully exposed by retraction. The horizontal ramus of the pubis is covered with a tough fascia, which is Cooper's ligament. A suture of tanned or chromic catgut in a small full curved needle is passed from Cooper's ligament going down to the periosteum and just internal to the iliac vein through the lower portion of the transversalis fascia and the edge of Poupart's ligament. The other sutures are placed internal to this one, the innermost suture picking up Gimbernat's ligament. These three interrupted sutures effectively close the femoral canal. The first suture is placed close to the iliac vein, which is retracted with a blunt retractor, and the tissues should be well in view before the suture is placed (Fig. 473). A few interrupted sutures of tanned or chromic catgut now approximate the conjoined tendon and the internal oblique and transversalis muscles to Poupart's ligament without transplanting the cord, or the round ligament, and the aponeurosis of the external oblique is sutured in a separate layer with a continuous tanned or chromic catgut ligature, as in the operation of Ferguson. This operation of Seelig, which is an elaboration and modification of the operation of A. V. Moschcowitz, and of Dujarier, is but slightly more difficult than the simple operation of exposing the sac from below Poupart's ligament and obliterating the femoral canal by a purse-string suture from below. In strangulation or in incarcerated hernia an operation of the type of the Seelig should always be done and where the femoral canal is large this operation will make the only satisfactory closure.

Occasionally when there is marked distention of the abdomen and the contents of the strangulated femoral hernia are tense it may be difficult by an internal incision to divide the femoral canal sufficiently to relax the constriction and deliver the intestines within the abdominal cavity. Then, too, when the bowel is apparently gangrenous or when perforation is imminent it may be wise to relieve constriction by cutting through Poupart's ligament from without inward and to inspect the strangulated hernial contents before an attempt is made at replacement within the abdomen. In such instances the aponeurosis of the external oblique is split as close to Poupart's ligament

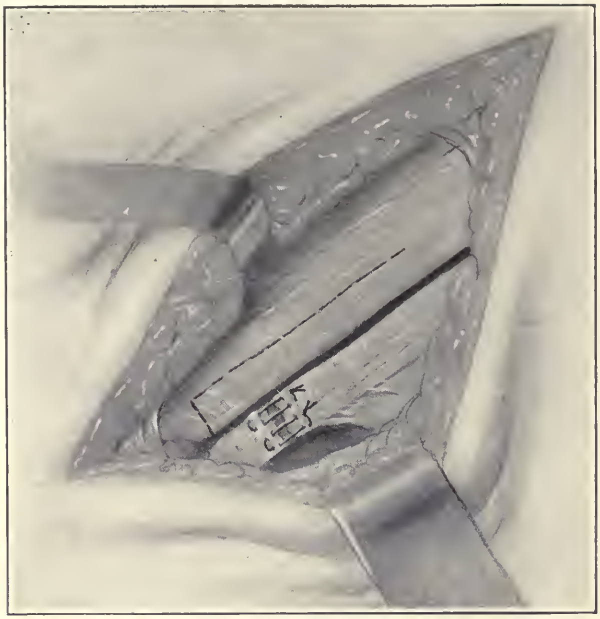

Fig. 474.—When it is necessary to divide Poupart's ligament, the ligament may be reconstructed by a flap from the aponeurosis of the external oblique. The drawing shows the lines of incision for such a flap.

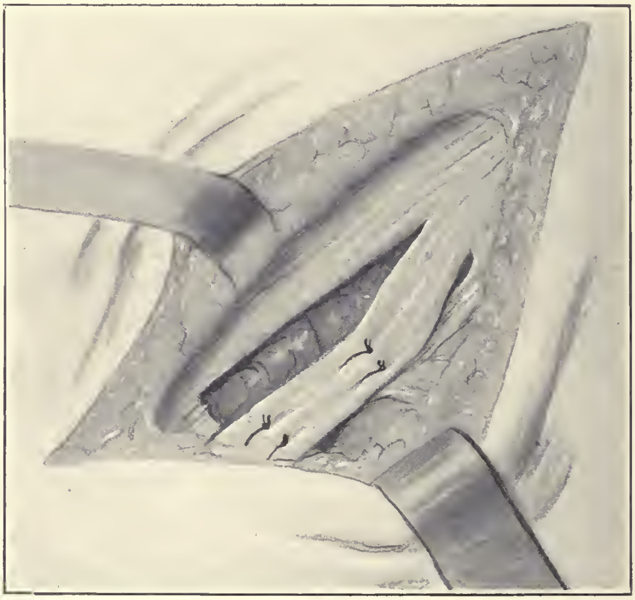

Fig. 475.—The flap has been sutured into position so as to reinforce Poupart's ligament.

as possible and Poupart's ligament is divided transversely. This should never be done except under the unusual conditions mentioned, for when Poupart's ligament is divided in this manner it is impossible to suture it together satisfactorily. The cut ends may be approximated with mattress stitches which are loosely tied, though it is impossible to bring them into contact because the sutures will split out. The internal margin of the aponeurosis of the external oblique can be divided transversely for an inch close to its insertion into the pubic bone and split up so that it has a base externally (Fig. 474). This flap is carried to the region of the divided Poupart's ligament and fastened securely to the outer and inner ends of the divided ligament, so closing the gap and acting as a splice between the two divided portions of Poupart's ligament. The end of this flap should also be sutured to Cooper's ligament along the margin of the pubic bone. The rest of the aponeurosis is brought down over part of its extent and with the conjoined tendon and internal oblique and transversalis is sutured to the reinforced Poupart's ligament (Fig. 475). I was compelled to sever Poupart's ligament once and this procedure was followed by satisfactory results.

UMBILICAL HERNIA

Umbilical hernias occur most frequently in fat persons. An operation that merely approximates the edges of the hernial ring after removing the sac is unsatisfactory. The technic devised by the Mayos has greatly improved the results of operations upon this type of hernia and is now generally adopted. The principle underlying the Mayos' operation is that of overlapping the wound from above downward. Formerly, when attempts were made to close this hernia by suturing the ring from side to side many of these stout patients succumbed to edema of the lungs or to failure of the heart because an extra burden was placed upon the lungs and heart by the constriction resulting from the longitudinal suturing of the hernial ring. If, however, the tissues are overlapped from above downward and if in the after-treatment the patient's thighs are elevated and a pillow is placed under the shoulders and head, there is comparatively slight discomfort. The incision is transverse and is made in an elliptical manner to surround the umbilicus and the hernia. The incision should be generous and if the patient is very fat a considerable amount of fat is included with the skin. The neck of the hernia is exposed and the aponeurosis for at least an inch and a half around the neck is dissected free of fat (Fig. 476). The sac is divided near the neck by an incision parallel with the opening of the neck and the hernial contents are exposed. The adhesions are freed and if there is adherent omentum it is ligated in sections and removed along with the sac. Care should be taken, however, to inspect the contents of the hernia from the opening near the neck of the sac in order to be certain that the nutrition of the bowel is not interfered with before ligating what seems to be merely omentum; for mesentery may be caught in the sac and may appear to be omentum. The edges of the neck of the sac and the

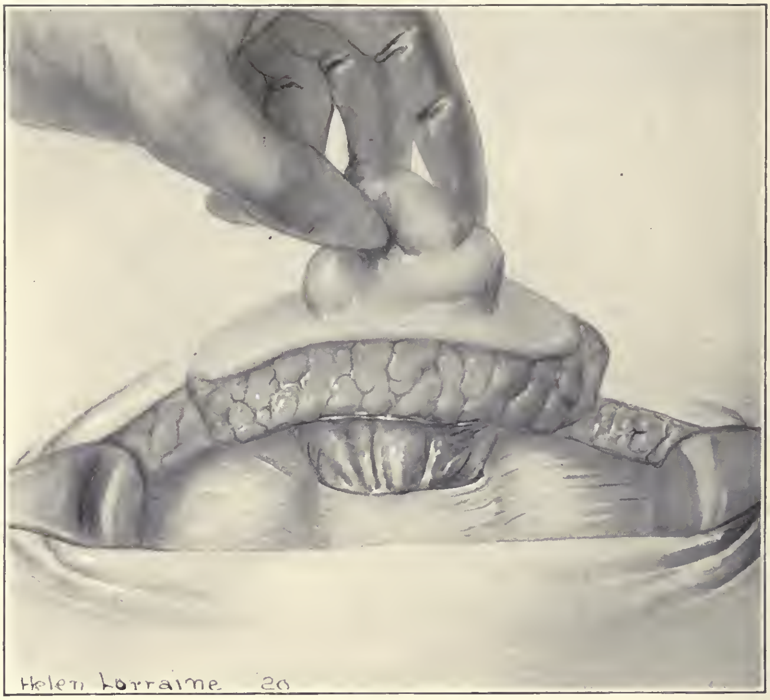

Fig. 476.—The neck of the sac of an umbilical hernia is exposed and is ready for incision.

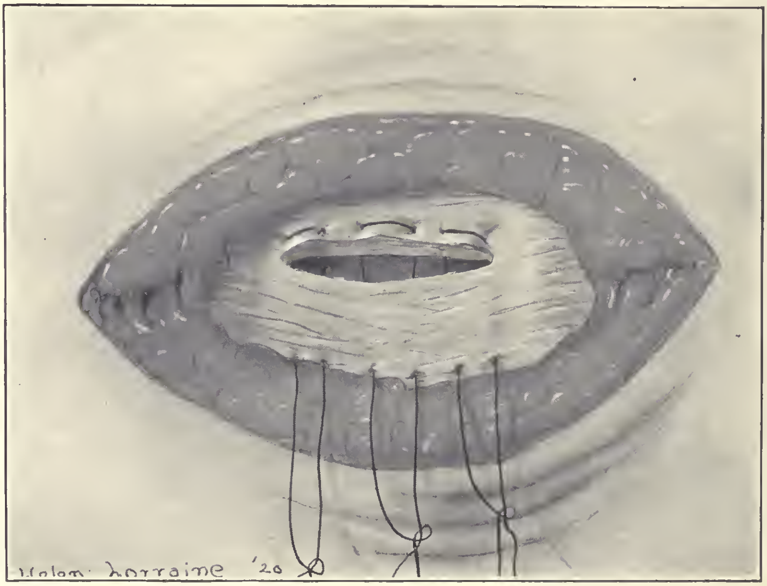

Fig. 477.—Mattress sutures for imbrication of the margins of the opening in the aponeurosis of the abdominal wall are placed.

margins of the umbilical ring are seized with forceps as the incision is continued around the neck of the sac. The sac should not be cut too close to the neck as all the peritoneal tissue and even thin fascia which can be saved add to the strength of the reconstructed abdominal wall. The intestinal contents are packed off with moist gauze. Exposure with a retractor should be ample while passing the sutures. The sutures are stout tanned or chromic catgut. The first suture is inserted in the midline about two inches below the lower margin of the umbilical ring, appears in the abdominal cavity and is carried to the upper margin of the umbilical ring where it takes a bite in the peritoneum and fascia, and then returning is passed from the peritoneal cavity outward at a point about one-half an inch to one side of the point of entrance. The ends are cut long and clamped

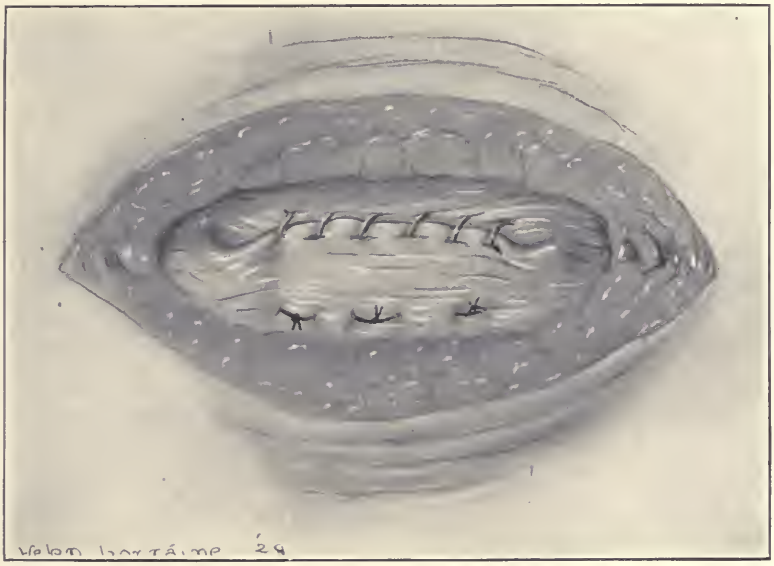

Fig. 478.—The mattress sutures have been tied snugly and the margin of the overlapped aponeurosis is sutured to the surface of the aponeurosis which it overlaps.

but not tied. One or more sutures are similarly passed on each side of this central suture. The number of sutures, of course, depends upon the size of the ring (Fig. 477). After the sutures have been placed they are all grasped at the same time and by traction the upper margin of the ring is imbricated under the lower margin. The sutures are tied one at a time while all are held taut. In this manner no undue tension is placed upon any single suture. The overlapping is ample to provide for a considerable retraction of the margins without a recurrence of the hernia. A continuous lock stitch of tanned or chromic catgut fixes the former lower margin of the ring of the umbilical hernia to the aponeurosis over which it now lies (Fig. 478). The skin is closed in the usual manner. It is well to introduce a small drain of catgut mat or folded rubber tissue in the outer angles

of the wound to give exit to the broken down fat that not infrequently occurs in stout people after this operation.

If the local conditions make it easier to carry the lower margin of the umbilical ring under the upper margin, instead of the reversed procedure which has just been described, this can be done, as it makes no essential difference in results. The important points are to free the external fascia from fat, to introduce the first mattress suture at a sufficient distance from the margin of the ring, to secure ample overlapping, and to bring all sutures up taut before any suture is tied.

INCISIONAL OR VENTRAL HERNIA

Incisional or ventral hernias follow injury to the abdominal wall, usually an operation, and are prone to occur after infection where union is poor or in stout individuals where the intraabdominal pressure is great. The combination of infection and fat is particularly liable to develop hernia. As infection plays a considerable part in the development of an incisional hernia, adhesions of the viscera to the sac are common. The explanation of the formation of these adhesions has been greatly clarified by Hertzler,[3] who has shown that adhesions are dense along the periphery of a severe infection and not in its center, as has been commonly supposed. Consequently, after a hernia following an abdominal infection the focus of the beginning of infection may be found free from adhesions while the viscera are well plastered to each other or to the peritoneum at some distance away. It is, of course, necessary to free the adhesions from the sac of an incisional hernia when operating to cure the hernia. While all adhesions in the abdominal cavity need not be freed, any single band or strong points of adhesions should be cut because they are more likely than broad extensive adhesions to cause obstruction.

The incision is so made as to include the scar in the skin from the previous operation. The peritoneal cavity is opened at the upper or the lower end of the incision, making an effort to enter just above or just below the margins of the hernia. Usually it is better to go in above, because most of these hernias occur in the midline and an incision below may involve the bladder. After entering the abdominal cavity the adhesions are freed, bluntly if possible, and the incision is carried down through the midline, freeing adhesions as the incision progresses. The sac which consists of peritoneum and thin bands of fascia is split down the middle. W. J. Mayo has called attention to the great value of peritoneum in operating on this type of hernias and the sac should never be cut away but should be preserved. After the adhesions have been freed the skin with the subcutaneous fat is separated on each side to a point well beyond the weakened thin wall of the hernia. Often the margins of the hernia are not sharp as in umbilical hernia, but gradually merge into healthy tissue. The margins are overlapped as de-

[3]Hertzler, A. E.: The Peritoneum, i, p. 276, et seq.

scribed in umbilical hernia, except that they are overlapped from side to side instead of from above downward. The first mattress suture of stout tanned or chromic catgut is taken preferably on the right side about one and a half or two inches from the apparent margin of the weak hernial tissue. This may be a distance of four or more inches from the edge of the incision in the hernial sac. The suture is carried in full view to the left margin of the sac and after catching the edge of the sac and its weak fascia a second bite with the needle is made farther back from the edge, taking care to secure at least fairly strong tissue. The bite should not go far enough out from the edge to include the thick healthy abdominal wall, because this would mean too much overlapping and too great strain upon the tissues, and, consequently, too much intraabdominal pressure with its resulting effect upon the heart and lungs. This suture is returned in a reverse direction and the ends are left long and clamped. After a series of these mattress sutures have been inserted care is taken to remove all gauze from the abdomen that may have been placed to protect the viscera while passing the suture. The sutures are held up taut while the margin of the left portion of the sac is slid under the margin of the right half. These sutures are tied one at a time while the others are held taut, making three or four ties to each knot. The right margin of the sac, which now overlaps considerable tissue, is attached to the fascia on the left side by a continuous lock stitch of tanned catgut. The skin is closed in the usual manner. This operation, which is based on the principles enunciated by W. J. Mayo of the great value of peritoneum in repair of this type of hernias, is much better than the anatomical dissection in the midline, for all tissues are saved, no possible support is wasted, and the double-breasted effect makes a recurrence improbable.

Occasionally a hernia occurs after a drainage operation for appendicitis through the muscle splitting McBurney incision. If the patient is kept in bed sufficiently long, hernia after drainage through a McBurney incision is rare, and when it does occur is usually not large. Occasionally, however, the tissue yields. Here an anatomical dissection is preferable to the overlapping method, because the wound is closed in layers and in the different planes of closure the lines of sutures are not parallel as in an anatomical dissection of a ventral hernia in the midline of the abdomen. In a ventral or incisional hernia following a McBurney incision the scar in the skin is excised so that only healthy skin is brought together when the wound is closed. This principle should be followed so far as possible in any secondary operation. The fascia of the external oblique is recognized in either the lower or the upper portions of the wound and is split a short distance from the margin of the hernia. The split edges of the aponeurosis of the external oblique are dissected up on each side, freeing them for some distance from the margins of the hernia and trimming away any irregular adhesions or masses of scar tissue. Under strong retraction the internal oblique and transversalis muscles are exposed and dissected free. The sac is then opened near its neck as in umbilical hernia. The adhesions are freed and damaged omentum

is ligated in sections and divided, removing the adherent omentum with the sac. The peritoneum is closed with a continuous mattress suture of catgut, and the margins of the internal oblique and transversalis muscle, which have been thoroughly mobilized, are brought together with sutures of plain or tanned catgut. The mobilization should be so complete that there will be no tension upon the sutures. The aponeurosis of the external oblique is sutured with a continuous lock stitch of plain catgut. The skin is closed in the usual manner.

EPIGASTRIC HERNIA

Epigastric hernia has been occasionally discussed in medical journals since Terrier's publications described this condition and his operations for its cure in 1885. It seems, however, to have attracted but little attention. Not infrequently small epigastric hernias are diagnosticated and treated as ulcer

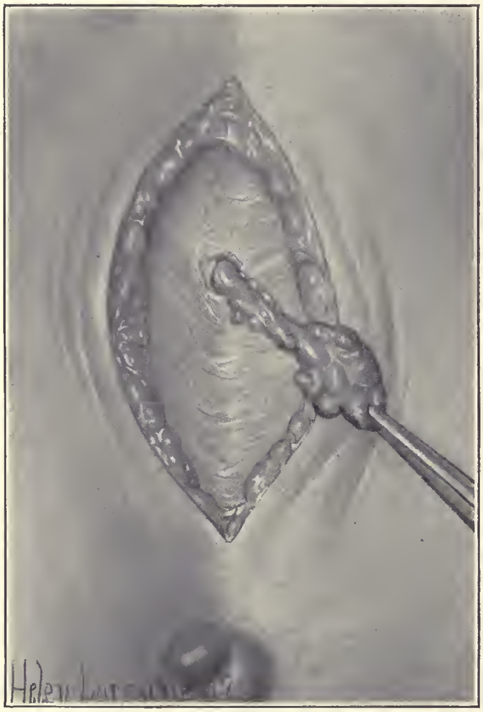

Fig. 479.—An epigastric hernia is exposed. It shows the protrusion of the subperitoneal fat through a defect in the aponeurosis in the midline of the epigastric region.

of the stomach or gall bladder disease. Epigastric hernia is situated in the anterior abdominal wall in or very near the linea alba between the umbilicus and the ensiform cartilage. It may occur in the linea semilunaris or sometimes in the lineæ transversæ of the rectus muscle. It varies in size from a small protrusion not more than a fourth of an inch in diameter which contains only properitoneal fat, to a large mass several inches in diam-

eter. The diagnosis of a large mass is obvious, but a small epigastric hernia with but slight protrusion and containing only properitoneal fat is sometimes easy to overlook. They are not infrequently multiple and this fact should be borne in mind when operating for this condition. The defect is usually congenital but when the hernia occurs in the linea semilunaris or in a transverse line of the rectus muscle it may follow an enlargement of the perforation of the blood vessels. In the midline a congenital defect such as is the cause of most hernias is the probable explanation for this hernia. The patient himself may discover a small lump no larger than the tip of the finger, which is painful and tender while he stands or sits, but disappears along with the symptoms when he lies down. Such symptoms are exceedingly suggestive of epigastric hernia. In very fat individuals it is sometimes difficult to feel the hernia even when the patient is standing.

An incision should be carefully made in the midline and carried down to the fascia before the fascia is divided. The fat is stripped away from the fascia for a distance of two inches on each side and the midline and the sheath of both muscles are fully inspected. If the opening is small it merely amounts to a protrusion of some properitoneal fat. This properitoneal tissue is well supplied with sensory nerves and when the intraabdominal pressure forces it through a small aperture pain is produced, which may be relieved when the patient lies down and the fat falls back into its normal place. An epigastric hernia with a large peritoneal sac usually gives but little discomfort unless there are adhesions or strangulation (Fig. 479). If the hernia consists merely of properitoneal fat there is no occasion for opening the abdominal cavity, but the fascia is split in the midline both above and below the hernia and overlapped for a distance of about half an inch, inserting two or more mattress sutures of tanned or chromic catgut in order to hold one edge of the fascia under the other and fastening the superficial edge to the fascia beneath it with a continuous lock stitch of tanned or chromic catgut. If the hernia is a large one and contains a well formed peritoneal sac, the sac is removed, leaving a sufficient margin of peritoneum in which to apply a continuous mattress suture without too much tension. The edges of the fascia are then overlapped, as has been described. The overlapping, however, should not be more than an inch, as more than this will produce too great intraabdominal pressure in this region and may embarrass respiration. As the sac in such a hernia does not contain elements of fascia as in an incisional hernia it had best be treated by excision of the sac instead of the overlapping described in operation on incisional hernia.

DIAPHRAGMATIC HERNIA

This condition is one of the many diseases in which x-ray has greatly aided the diagnosis. While, as Balfour says, it is not exceedingly rare it is uncommon. Diaphragmatic hernia may be purely traumatic, as from a stab wound, or a gun shot injury which involves the diaphragm; or it may be the

result of a congenital weakness of the diaphragm, usually around the esophageal opening. This weak point may give way from pressure that under normal conditions is readily withstood. Bevan records a case that was apparently due to a distended colon from chronic obstruction due to cancer of the left side of the colon. It is important to recognize whether the hernia is purely traumatic or is due to a congenital weakness, because the location of the incision and the type of operation are usually quite different in these two types. Diaphragmatic hernia due to direct injury is usually along the periphery of the diaphragm and the hernia may occur immediately or may follow months or years after the injury. Here the best approach is probably through the thorax. In the congenital type the hernia occurs around the esophageal opening in the diaphragm, and in such a location the site of the hernia is most accessible through an abdominal incision, as it would be difficult to reach the defect through the thorax.

The hernia can often be located by the x-ray. A portion of the stomach is frequently found in these hernias whether they be traumatic or congenital. Other viscera are also often contained in a diaphragmatic hernia. The case of Bevan, which has already been referred to, contained a portion of the dilated transverse colon through an opening around the esophageal outlet of the diaphragm. Roentgenographic examination should be made not only of the stomach but of the complete gastrointestinal tract.

Stuart McGuire, of Richmond, has had some interesting cases in which the approach was through the thorax. Here the incision may be intercostal over the apparent site of the hernia. Such an incision should be long and held open by rib spreaders. Resection of the eighth or ninth rib might give better exposure. In any event the incision should be sufficiently long to afford ample access to the site of the hernia. The lung is packed off with an abundance of moist gauze, which is not too hot, as excessive heat will probably do more harm than having the gauze too cold. After the hernia is reduced the diaphragmatic opening is closed by interrupted sutures of tanned catgut. This closure is made in the line of least resistance and if this does not correspond to a straight line the closure may follow the outline of a T or an L. After inserting the interrupted sutures, if there is not too much tension, a separate row of tanned catgut sutures may be placed over the first row.

In the congenital type of diaphragmatic hernia the abdominal approach is much superior to thoracic incision. An excellent exposure is made by the S-shaped incision of Bevan, which begins just below the ensiform cartilage and goes outward parallel to the costal cartilage to the middle or outer portion of the rectus muscle, then downward to about the level of the umbilicus and then slants outward again. The hernial contents are reduced by traction. Sometimes this is best done by opening the lesser peritoneal cavity and pulling down the contents from behind the stomach. Traction must be made very carefully, as hemorrhage due to rough manipulation in this neigh-

borhood is embarrassing. The suction of the pleural cavity during respiration tends to draw the abdominal contents back through the hernial opening and this adds to the difficulty of the operation. The hernial opening is closed with stout tanned or chromic catgut in much the same manner as the conjoined tendon is sutured to Poupart's ligament in an inguinal hernia. The opening is sutured snugly around the esophagus. Balfour found that a large opening in the diaphragm was best closed by suturing it in a T-shaped manner, suturing the anterior portion in a straight line and the posterior portion in a line at a right angle to the anterior row of sutures. It is exceedingly important to place the sutures so they will have a minimum of tension. The omentum near the stomach or near the colon may be fixed to the abdominal wall by a few interrupted sutures of catgut so there will be less tendency for these viscera to return to the hernial site. If intratracheal anesthesia is available and can be skillfully given it will add considerably to the ease with which this operation can be done, though it is not a necessity. The patient is placed in bed in the head elevated position to reduce the pressure upon the diaphragm by the abdominal viscera.

Other forms of internal hernia are occasionally met, but they require no special type of operation. The diagnosis of such cases is very infrequently made before operation and the operation is usually performed to relieve symptoms of intestinal obstruction. Hernia of the small intestines through the rent in the mesocolon after gastroenterostomy was formerly a rather common occurrence. This is avoided by suturing the edges of the opening of the mesocolon to the stomach wall, which is best done according to the suggestion of McArthur by placing the posterior sutures between the rent in the mesocolon and the posterior wall of the stomach before the stomach and jejunum are clamped. Hernia into any of the intraabdominal fossae requires reduction with closure of the fossa if possible by tanned or chromic catgut. The treatment of the intestine depends upon the condition of the intestine and may demand a resection, or an enterostomy, or both.

CHAPTER XXIII

ABDOMINAL INCISIONS

The first and last stages of every abdominal operation are, respectively, the making and the closing of the incision; and they constitute an important part of the success or failure of the operation. The location of the incision depends largely upon the region of the abdomen to be operated upon. Satisfactory exposure is always not only desirable, but usually necessary, though there may be different views of what constitutes satisfactory exposure. In acute appendicitis, for instance, an incision over the region of the appendix that is just large enough to admit the finger for palpation is often satisfactory, but in chronic appendicitis, or particularly where bands or other pathology are suspected, a short incision which merely permits removal of the appendix without other examination of the abdominal viscera, is often followed by a continuance of the patient's symptoms. Here an incision near the midline with exploration either by palpation or sight of all the abdominal viscera should be made.

In operations upon the upper abdomen many surgeons employ a transverse incision, claiming that the aponeurosis of the muscles of the abdomen is least injured by it, and that the nerves, particularly the nerves to the recti muscles, are saved. If a transverse incision is made in the upper abdomen it will be necessary to divide the recti muscles, and in order to secure their ends they are sutured to the aponeurosis in front and behind before they are divided. This may be done by making an incision through the skin and superficial fascia down to the aponeurosis, opening the abdominal cavity in the midline just enough to admit the finger and then fastening the recti muscles to their sheaths by two parallel rows of sutures through the anterior and the posterior sheath. The abdominal contents are protected during this suturing by inserting the finger through the small median opening. These sutures, according to Willy Meyer, should preferably not enter the peritoneal cavity, and this may be accomplished by using a strong full curved needle. After these rows of sutures are placed the recti muscles with the fascia are divided transversely between the stitches and the wound is retracted. Occasionally such an incision may be advisable, but as a rule the longitudinal incision or the modified longitudinal incision gives the best exposure and is easily closed.

For operations on the gall bladder, the bile ducts, or the pyloric end of the stomach, the Bevan incision or a modification of it gives excellent exposure. This incision begins just below the ensiform cartilage, runs downward and

outward to about the middle of the rectus muscle, and then downward to a little above the level of the umbilicus, when it is again carried downward and outward for two or three inches. The fascia is divided along the straight incision and the rectus muscle in the direction of its fibers. If it is necessary for a full exposure the rectus muscle is cut across obliquely along with the fascia at the upper part of the wound and also at its lower portion. It is not often necessary to make the oblique incision through the rectus muscle at the lower portion of the wound but it can be done with but little complication in closing the wound or in weakening the abdominal scar.

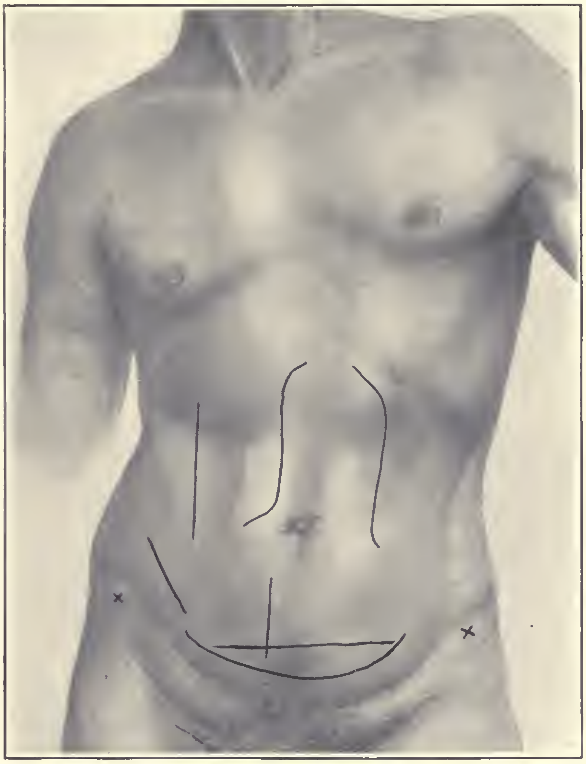

Fig. 480.—Lines for abdominal incisions. The incisions near the midline in the epigastric region are the Bevan incisions, right and left. The vertical incision to the outer side of the right Bevan incision is the intraabdominal incision for nephrectomy. The incision near the right anterior superior iliac spine is the McBurney incision for appendicitis. The lowest curved incision is the Pfannenstiel incision. Just above this is the transversed incision of Judd for double hernia. An incision to the right of the midline between the navel and the pubis is for general pelvic and lower abdominal work.

Through such an incision most operations in the right upper abdomen can be performed and access to the gall bladder and gall ducts, pylorus and pyloric end of the stomach is excellent (Fig. 480). This incision is also quite satisfactory when applied to the left side.

A median incision above the umbilicus is sometimes employed though it should, as a rule, be avoided. A median incision either above or below the umbilicus, while avoiding injury to any nerves that may supply the recti muscles, cuts through a thin portion of the abdominal wall where the fascia af-

fords unsatisfactory margins for a sound scar. Of course, in epigastric hernia a median incision closed by slight overlapping of the aponeurosis is essential. If an incision is carried through the rectus muscle, closure is more satisfactory because two distinct layers of fascia and the rectus muscle between them add a bulk of large stable tissue to the edges of the wound, instead of merely a thin single plane of fascia as occurs in the median line. If an incision is made along the inner third of the rectus muscle, or if the fibers are split along the junction of the middle and inner thirds but little of the rectus muscle is affected by the destruction of the nerve supply, and the proper suturing of the aponeurosis of the large flat muscles of the abdomen, which constitutes the anterior and posterior sheath of the rectus muscle, should secure satisfactory union.

If the surgeon is not fully satisfied of the necessity of a long incision in the upper abdominal region, as in explorations about the gall bladder, the central part of the Bevan incision may be made and, if the occasion demands, the incision can be extended both upward and downward. Not infrequently when it is desired to explore the gall bladder and remove the appendix, the appendix may be removed through a McBurney incision and the condition of the gall bladder ascertained through a short two inch incision through the rectus muscle. This incision over the gall bladder is made first because if the gall bladder is found diseased the incision is extended and the appendix removed through this one incision, but if there is no trouble with the gall bladder or the structures in its neighborhood this wound is closed and the appendix removed through a McBurney incision.

Operations on the cardiac end of the stomach, for diaphragmatic hernia, or on the spleen, are satisfactorily done through a left Bevan incision. This begins as on the right side just below the ensiform cartilage, goes downward and outward parallel with the edge of the left costal cartilage to about the middle of the rectus muscle, then vertically down to just above the level of the umbilicus, splitting the fibers of the rectus muscle, and then downward and outward obliquely for a sufficient distance to give satisfactory exposure. By carrying the vertical portion of this incision nearer to the outer border of the rectus muscle a somewhat better exposure of the spleen is obtained than if the vertical part were nearer the middle of the muscle. This, of course, must be left to the exigencies of the case, but it should also be remembered that the nerves of the recti and other abdominal muscles run in the upper abdomen approximately a transverse course and more of the rectus muscle will be saved if the vertical incision is made nearer toward its inner border.

Removal of the kidney when indicated because of considerable enlargement, such as a tumor, is often best done through a vertical incision along the outer border of the rectus muscle. This should extend from just below the margin of the costal cartilage to well below the level of the umbilicus. The peritoneal cavity may be opened though often the peritoneum can be stripped away from the abdominal wall and the pedicle of the kidney reached without opening the peritoneum. Whether this is done depends, of course, upon the size, shape, and character of the kidney growth.

An incision for umbilical hernia should be transverse, and usually elliptical including the umbilicus along with the surrounding skin in the mass of tissue to be excised. If there is occasion to make a long incision near the umbilicus, as for the removal of an intraabdominal tumor in its neighborhood, the incision is supposed to be placed to the left of the umbilicus, because the round ligament to the liver goes somewhat to the right of the midline from the umbilicus to the liver. Such an incision, however, is but rarely indicated. It is best to excise the umbilicus while making this incision in order that the wound may be more satisfactorily closed. Occasionally, in operations upon the cardiac end of the stomach or for a tumor of the liver that is difficult of access an atypical incision must be made. Sometimes it may be advisable to make a flap, such as is used in exposure of the heart, with the base outward over the ribs, with two transverse parallel incisions and a third incision connecting the two ends of the parallel incisions at the midline. The ribs and costal cartilage are divided or fractured and the flap is turned back for full exposure.

In operations upon the lateral margins of the abdominal wall the kidney is the most frequent object of attack. Here the incision of W. J. Mayo gives exceedingly satisfactory exposure and inflicts a minimum of injury on the abdominal muscles. This incision can be used in operations on the kidney, the pelvis of the kidney, or the upper ureter. It begins at a point about two and a half inches external to the spinous process of the lower dorsal vertebrae near the outer margin of the erector spinae muscle over the upper border of the twelfth rib, or even higher. (Fig. 590.) The incision is carried downward and somewhat forward along the outer margin of the quadratus lumborum to about an inch above the crest of the ileum, where it is carried forward parallel to the crest of the ileum as far as may be necessary for satisfactory exposure. The triangle just beneath the twelfth rib at the upper portion of the wound is exposed by incising the external and the internal oblique, the transversalis and the latissimus dorsi muscles and the transversalis fascia is freely opened. The twelfth rib is well freed along its lower border almost to its articulation and the rib is retracted strongly upward while the erector spinae muscle is retracted backward. Sometimes the twelfth rib may be dislocated or fractured to give even larger exposure. The muscles are divided along the lower part of the wound as far as may be necessary in the general direction of the skin incision. Care should be taken to avoid injury to the iliohypogastric and the ilioinguinal nerves.

When fixation of the kidney is contemplated a shorter incision, such as was employed by Edebohls, is satisfactory. Here the twelfth rib and the erector spinae muscle are recognized and a vertical incision is made from the twelfth rib downward close to the outer edge of the erector spinae muscle. This goes almost to the crest of the ileum. The fibers of the latissimus dorsi are exposed and are split, but not cut across. The erector spinae is retracted inward but its sheath is not opened. The sheath of the quadratus lumborum is opened along its outer margin for the whole of the wound. By keeping about

one inch below the rib injury to the pleura may be avoided. The transversalis fascia is divided and the perirenal fat is exposed. The iliohypogastric and the ilioinguinal nerves must be protected at the lower portion of the wound.

Incisions in the abdomen for operations below the umbilicus are often made. In acute appendicitis where there is no reasonable doubt of the diagnosis, the McBurney incision is most satisfactory. This is made in the direction of the fibers of the external oblique and is about two inches long with the center of the incision on a line between the anterior superior spine and the umbilicus, and about one and a half or two inches from the anterior superior spine. In women when an exploration of the pelvic organs is desired, the incision is carried much lower and further inward. After cutting down to the aponeurosis of the external oblique, this aponeurosis is split in the direction of its fibers throughout the length of the skin incision. The iliohypogastric nerve is identified, and the fibers of the internal oblique and transversalis muscles, which run practically parallel in this region, are separated at a sufficient distance above the nerve to avoid its inclusion in the sutures when the incision is closed. Failure to do this is often followed by an unnecessarily painful scar. The fibers of these muscles are best divided by inserting the points of closed blunt-pointed scissors and then spreading them in the direction of the fibers of the muscle. Two fingers are placed between the separated fibers to enlarge the incision. Then retractors hold the split fibers apart while the peritoneum is incised. (Figs. 561-564.) If this incision is made further inward and downward, not infrequently the deep epigastric vessels appear along its inner margin and they must be retracted or doubly clamped and divided. Here the fibers of the internal oblique and transversalis terminate in an aponeurosis which may be split in the direction of its fibers, and the margin of the rectus muscle is strongly retracted inward without being divided.

In general exploration of the lower abdominal cavity an incision just to the right of the midline is very satisfactory. This may be carried from about the level of the umbilicus to the pubis. The sheath of the rectus muscle is cut along the junction of the middle and inner thirds of the muscle. If the incision is made nearer the midline too little support is furnished the sutured wound by the rectus muscle, while further out too much of the rectus muscle is injured by destroying its nerve supply. After incising the fascia the fibers of the rectus muscle are split and held apart by retractors while the peritoneal cavity is opened. Sometimes the epigastric artery runs in this region and not infrequently a large branch is given off which may cross the line of incision at its upper portion. Some operators advise retracting the muscle outward instead of dividing its fibers in order to save all of the nerve supply. As below the semilunar fold all of the aponeurosis that constitutes the sheath of the rectus is in front of the rectus and none behind, this dislocation of the inner edge of the rectus muscle may make a weak spot that would not occur if the muscle were left attached along its inner border and its fibers split.

Operations upon the sigmoid and the left colon may be done through an incision somewhat to the left of the midline made in the same manner as has just been described for incision to the right of the midline. If it is planned to resect the bowel for cancer an ample incision along the outer border of the rectus muscle will be necessary. The incision of Sir Astley Cooper for exposure of the iliac vessels is now rarely if ever employed, because the iliac vessels can be much better exposed by an incision somewhat to one side of the midline with the patient in the Trendelenburg position. The old incision was advised because of the ancient surgical fear of entering the peritoneal cavity.

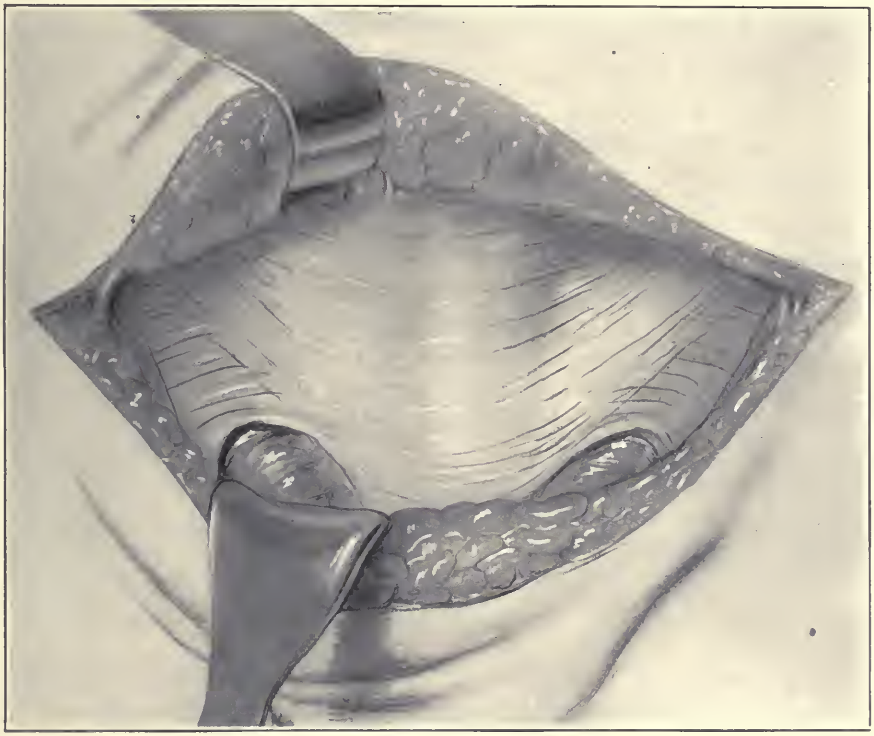

Fig. 481.—The incision of Judd for double inguinal hernia.

The bladder may be exposed by a median incision running up from the pubis for a sufficient distance. Here the recti and the pyramidalis muscles overlap and there is an abundance of muscle fibers to protect the wound if conditions permit of primary suturing of the muscle.

A transverse or Pfannenstiel incision is used by some operators for exposure of structures in the pelvis. This is carried across the abdomen with a slight convexity downward, the lowest point of the convexity lying about two inches above the pubis. The incision may be so placed that most of it comes within the region of the pubic hair. The skin and subcutaneous tissue are dissected up along the upper margin as a flap. The aponeurosis of the external oblique is divided in the general direction of the skin incis-

ion. The upper portion of the flap of the aponeurosis is dissected and a vertical incision is made between the recti muscles. This gives satisfactory exposure and in certain instances may be indicated. If there is any suspicion of infection, however, it should not be employed for too much raw surface is exposed. It is also difficult to enlarge this incision satisfactorily if the surgeon finds that more space is necessary than he had first anticipated.

An excellent incision in double hernias is that which is used by E. S. Judd (Fig. 481). It is a transverse incision from just external to one internal inguinal ring to a corresponding point on the opposite side. Both hernias can thus be readily exposed. It is, of course, only carried through the skin and superficial fascia, the rest of the hernia being operated upon according to the technic that may seem indicated.

CLOSURE OF ABDOMINAL INCISIONS

The method of closing abdominal incisions depends partly upon the character of the incision and largely upon whether it is located above or below the umbilicus. The physiologic action of the muscles of the abdomen and the movement of the abdominal contents is so different in these two regions that the procedures for closing incisions made above or below the navel must differ materially. Below the umbilicus there is but little motion of the abdominal muscles. The aponeurosis below the semilunar fold of Douglas is in front of the recti muscles instead of being half in front and half behind as it is above this point. The recti muscles themselves act as a buffer and take considerable strain from the thick aponeurosis in front but where the aponeurosis splits above the semilunar fold of Douglas, half going in front and half behind the recti, if the posterior layer is not accurately closed its retraction forms a point of least resistance and the abdominal contents can easily force apart the fibers of the rectus. A potential hernia results.

Incisions below the umbilicus are frequently made just to the side of the midline so that the portion of rectus muscle between the incision and the midline is very small, and even if it looses its nerve supply but little harm is done. Above the umbilicus, however, incisions are rarely made in the midline and are usually along the middle or outer portion of the rectus so that a considerable portion of this muscle may be deprived of its nerve supply and can hardly be depended upon to resist the intraabdominal pressure.

The main reason, however, for the difference in the types of suturing above and below the umbilicus is the motion of the muscles. Below the umbilicus there is comparatively little muscle movement during normal respiration, whereas above the umbilicus it is always pronounced. The action of the diaphragm, which forces the liver and stomach up and down during respiration, and the expansion and contraction of the thorax cause considerable motion of the upper abdominal wall during each respiratory act. When there is vomiting or any unusual tension within the abdomen, particularly with

the patient lying in bed, the maximum force appears to be exerted around the epigastrium, as the very act of vomiting means that the stomach itself is compressed by the action of the diaphragm and the abdominal muscles which lie over the stomach.

It is not generally safe to trust to layers of catgut sutures in any wound above the umbilicus. The insertion of a number of interrupted sutures of catgut may be safe, but the constant motion of the muscles in this neighborhood makes a softened or weakened catgut suture likely to give way and the abdominal contents may protrude beneath the skin or through the skin wound itself. To obviate this some operators insert tension sutures of silkworm-gut in addition to the catgut sutures. These are placed after closing the peritoneum but before suturing the muscles or fascia. The muscles and fascia are then closed with separate layers of catgut sutures and the skin is sutured in the usual manner, the tension sutures being tied last of all and the skin protected either by placing gauze over the skin wound and tying the sutures over them, or by threading the sutures through a segment of fine rubber tubing. This method is usually satisfactory but it seems unnecessary to insert the catgut sutures because it places an additional burden of absorption on the tissues, cuts off a certain amount of nutrition from the edges of the repairing wound, and to some extent permits small cavities to form between the layers of sutures. If an operator feels that it is necessary for purposes of safety to insert four or five tension sutures of silkworm-gut, as he knows this material will hold, it seems a simpler matter to add a few extra silkworm-gut sutures, making the number eight or ten, and depend solely upon them. This method was found very satisfactory in the early days of surgery and has been used with much success by the late Joseph Price and his successors. The scar left is not as smooth as the scar after careful layer suturing, but when tension sutures are added to layer sutures there is but little difference in the scar. If the wound is closed by through and through sutures of silkworm-gut which are inserted at intervals of about three-fourths of an inch it is best not to close the skin with a continuous suture. If this is done any broken down fat or serum that may accumulate in the grasp of the interrupted suture cannot find a ready escape and may predispose to infection.

In closing incisions above the umbilicus which are either transverse or nearly transverse, the recti muscles should be fixed to their sheaths before being divided. This method as used by Willy Meyer and others has been described. Here the wound may be closed with interrupted catgut sutures but silkworm-gut is excellent. The tension on a transverse wound during straining or vomiting is marked because of the action of the recti muscles.

In closing other types of incisions above the umbilicus which are either longitudinal or oblique, the edges of the peritoneum are grasped with hemostats so that the peritoneum is drawn well into the wound. Stout silkworm-gut in a large needle is inserted, beginning at the lower end of the wound, taking a small bite of skin, a considerable amount of the fascia over the rectus muscle, a small part of the muscle, and a generous bite

of the posterior aponeurosis and peritoneum. The needle is returned from within out in a similar manner and each end of the suture is grasped with a large hemostat. If one wishes to be particularly careful each end of the silkworm-gut may be threaded on a needle and inserted from within outward. This, however, seems to be an unnecessary refinement for unless there are twice as many needles as there are sutures if the needle is passed from within outward it must eventually penetrate the skin, and each time it penetrates the skin it may become contaminated, when it should be either boiled or discarded. As a matter of practice when the skin has been well disinfected there seems but little danger in inserting the needle from without inward on one side and from within outward on the other, as has just been described. These sutures are all placed before they are tied and the ends of each suture are grasped with hemostats. After they are all placed an assistant and a nurse forcibly raise the ends of the sutures on each side of the wound so that the edges of the wound are slightly lifted up. The operator then presses together the abdominal wall on each side of the wound, thus forcing the peritoneum together because it must slide down on each side of the suture to what corresponds to the apex of a triangle (Fig. 482). While the sutures are held in this position they are tied one at a time, just snugly enough to obtain reasonably firm closure. The assistant and nurse hold the other sutures, merely releasing one as it is about to be tied. In this way the sutures are tied under equal tension and evenly. If this precaution is not taken the patient sometimes strains before all the sutures are tied and breaks them or tears the tissues and to secure coaptation it may be necessary to tie the sutures quite tightly which, of course, produces necrosis and predisposes to infection. If there is equal tension on each suture, however, and they are tied in the manner described, the strain on the wound is distributed over the combined sutures in the same manner as the strain on the strands of a cable, which can withstand great tension as long as the strands are together, but if they are separated it will easily snap. Furthermore, the peritoneum is brought well in apposition and as all the structures of the abdominal wall are held in uniform tension in the grasp of the same suture there is less tendency for any one structure to be cut by the suture. These sutures are left in about ten days or two weeks. It is best not to take them all out the same day, but to remove half of the sutures at one time and the other half a few days later.

In wounds near the midline below the umbilicus layer sutures are satisfactory except where pus is encountered in the abdominal cavity or where by reason of contamination there seems a probability of infection of the wound. Here through and through sutures should be placed in the same manner as above the umbilicus. In suturing a wound in layers below the umbilicus the peritoneum is brought together by fine continuous mattress sutures of tanned or chromic catgut. The suture is begun at the lower angle of the wound and the short end is tied and clamped with a hemostat to hold it steady. The suture is carried back and forth as a continuous mattress stitch,

catching a good grasp on the transversalis fascia and the edges of the peritoneum. A mattress suture used in this way turns out the raw edges, exposes no raw surface to the abdominal cavity, and secures a firm hold on

Fig. 482.—Method of closing incisions above the umbilicus.

the delicate peritoneum. The suture is tied at the upper angle of the wound. The wound in the rectus muscle is closed with a continuous lock stitch of plain catgut and is brought together with very little tension. Muscle is highly organized tissue and withstands pressure badly. The merest approximation

of the divided fibers of the rectus is much better than a tight suture because the tight suture will cut the muscle or impair its nutrition. The aponeurosis or the external sheath of the rectus muscle is closed with a continuous lock stitch of tanned or chromic catgut, about number one in size. If this row is accurately applied there is no need for further reinforcing it except possibly where it is anticipated that there will be considerable distention. Here a few interrupted sutures of tanned or chromic catgut are placed through the fascia over the continuous lock suture and going well back into the fascia. It must be borne in mind, however, that extra tension sutures are not entirely without danger because the relief of tension on the midline sutures also means cutting off nutrition to the edges of the fascial wound which may delay healing, though in some instances tension sutures may be justifiable. The skin is closed with a continuous subcuticular suture of 00 tanned or chromic catgut. If the skin is very thin and flabby a continuous mattress suture of fine tanned catgut is used. No tension suture other than those just mentioned should be used when an abdominal wound is closed in layers. If tension sutures of silkworm-gut are demanded, it would be much better to use a few more and close the whole wound with silkworm-gut, as has been described for incisions above the umbilicus.

In the McBurney or muscle-splitting operation the wound is closed in layers with catgut. The peritoneum here may be united with a mattress or a purse-string suture of plain catgut. The transversalis and internal oblique muscles, whose fibers have been split, are closed with a few sutures of plain catgut. A continuous lock stitch of plain catgut is used in the aponeurosis of the external oblique and the skin is closed with a continuous subcuticular suture of fine tanned or chromic catgut. Muscles are particularly irritated by chemicals in catgut, so when muscle is united to muscle, plain catgut which is readily absorbed should be used; though when muscle is united to fascia, as in a hernia operation, tanned or chromic catgut is advisable.

In drainage cases of appendicitis where the McBurney incision has been made, one or two interrupted silkworm-gut sutures are used, catching all layers of the abdominal wall and tying the sutures close to the tube or cigarette drain which comes out at the outer angle of the wound. To prevent pocketing the rest of the wound is lightly packed with iodoform gauze.

In operations on the kidney the lower portion of the incision may be difficult to approximate accurately by through and through interrupted sutures, and these wounds can be closed in two layers, using tanned or chromic catgut either in a continuous lock suture or as interrupted sutures. The through and through method, however, is excellent here. At the upper posterior angle a drain is brought out. The transverse incision of Pfannenstiel is closed by suturing the peritoneum in the usual way, the fibers of the rectus muscle with a loose continuous lock stitch of plain catgut, and the aponeurosis of the external oblique and the sheath of the rectus with a continuous lock stitch of tanned or chromic catgut. The skin may be closed by a continuous mattress suture of fine tanned or chromic catgut, or with horsehair, fine silkworm-gut or silk. These latter materials pro-

duce somewhat less reaction than catgut and eventually make a somewhat less conspicuous scar than is obtained even by an accurate subcuticular suture of fine catgut. Where the inconspicuousness of the scar is a very desirable point, as in operations about the face and neck, catgut should not be used, as has already been explained, but in wounds of the abdomen a subcuticular suture of fine catgut makes a very satisfactory scar with no stitch marks, and the patient is often gratified that there are no stitches to be removed.

In suprapubic operations upon the bladder where the peritoneum is not entered there is nearly always drainage and here interrupted sutures of silk-worm-gut are very satisfactory.

CHAPTER XXIV

OPERATIONS ON THE LIVER, GALL BLADDER, BILE TRACTS, PANCREAS AND SPLEEN

Operations upon the liver itself are not common. Occasionally an abscess or a tumor requires operation and this must be done according to a certain definite technic. Sometimes, too, ptosis of the liver requires correction, though, as a rule, when this occurs the presence of other prolapsed organs, together with the peculiar structure of the abdominal wall in these cases, makes an operation for prolapse of the liver unsatisfactory. When the prolapse is in the neighborhood of the gall bladder, suturing the gall bladder to the abdominal wall helps to correct the ptosis. A U-shaped incision is made in the abdominal wall with its concavity upward and around the lower circumference of the prolapsed portion of the liver. The transversalis fascia is cut down upon but is not incised except at the lowest portion of the wound where a transverse cut is made through the transversalis fascia and peritoneum. The other tissues in the U-shaped incision are raised from the transversalis fascia and peritoneum. At the upper level of the reflected flap another transverse incision is made parallel to the one below it and a portion of the loose lobe of the liver is tucked into the pocket thus formed and fastened with sutures.

When there is complete prolapse, the liver may be replaced and fastened by passing coarse sutures of catgut or silk along the anterior edge of the liver and tying them to the cartilages of the ribs. About six or eight of these sutures may be passed. It is also necessary to take up the slack in the abdominal wall below the liver in order to afford support. This may be done by removing an oval-shaped area of skin and fascia from the midline of the abdominal wall and suturing the edges together after slightly overlapping them. In the method of Depage, a horizontal incision is made from the tip of the eleventh rib on one side to that of the eleventh rib on the other, and then incisions are carried downward and inward from the extremities of this horizontal incision to about the level of the umbilicus, terminating external to the umbilicus. These incisions are one-half the length of the original transverse incision. From the ends of these incisions on a level with and external to the umbilicus, an ellipse is made which terminates just above the pubis. All the tissues included in these incisions are removed and the wound is sutured to make a T-shaped scar.

Operations for hepatic abscess are common in tropical or semitropical countries. The kind of operation depends upon the location of the abscess and may be through the thoracic route or through the abdominal route.

Occasionally the abscess may be so situated as to render either one of these routes permissible, when a choice will depend to a large extent upon the adhesions around the abscess. The final diagnosis is the aspiration of the abscess. If this is followed immediately by operation through the track of aspiration but little harm is done, but if pus is found and the operation is postponed for a day or two, the pus may leak along the needle track and infect either the peritoneum or the pleural cavity, according to the region through which the needle was introduced. If a fine needle is used such a danger is reduced to a minimum, but the pus is often thick and cannot run through a fine needle so it may be necessary to use a coarser one. If the abdominal route is chosen for opening an abscess which is adherent to the parietal peritoneum the situation is much simpler if the incision can be made through the area of adhesions. Not infrequently, however, this is impossible and if the liver has been exposed and found to be free from adhesions the region of the abscess must be surrounded with gauze and aspiration repeated. If pus is obtained an opening is made by thrusting in sharp-pointed forceps and stretching them, or by inserting the actual cautery. If it is possible to do so, it would be better to pack around the abscess and then open it after forty-eight hours. Sutures in an inflamed liver will rarely hold and iodoform gauze packing must be used, but a few sutures of coarse catgut inserted at a short distance from the region of the abscess serve to hold the liver against the abdominal wall before the packing is placed. The sutures, of course, cannot replace the packing and alone will not prevent the contamination of the abdominal cavity. They merely serve to lessen the amount of packing necessary. The abscess cavity is explored with the finger to determine the possibility of a pocket or a secondary abscess before a tube is inserted. After introducing a large tube, gauze is packed around it and to prevent its displacement the tube is fastened to the edge of the wound with a suture of silkworm-gut. The tube may be connected with a retainer into which the pus is drained or it may be necessary for the pus to drain on the dressings which are frequently renewed. It is probably best not to irrigate these cavities.

When the abscess points toward the diaphragm it is opened through the thorax. After locating the abscess by an aspirating needle, about two inches of the ninth or tenth rib are excised over the region of the abscess and the pleural cavity is protected by suturing or by packing with gauze held in position by a few catgut stitches. The aspirating needle is again used, and following it as a guide the abscess in the liver is opened by thrusting in closed sharp-pointed forceps or by the actual cautery.

The chief difficulty in excision of a tumor of the liver is the control of hemorrhage. If the tumor is small and situated along the margin of the liver but little trouble is experienced. The incision may be made with an electric cautery and a V-shaped portion of the liver removed, which includes the tumor, the wound being closed with coarse catgut sutures. These sutures are inserted with a large blunt-pointed liver needle, or a large curved needle is

thrust through the liver eye first, is threaded and then withdrawn. A probe can also be used in emergency, the suture being hitched around the blunt end of the probe or passed through the eye at the other end if the probe has an eye at its opposite extremity. In a large tumor an effort may be made to control the bleeding temporarily by an elastic tube thrown around the pedicle of the growth or carried through the liver itself by a cannula. A cannula through which a small soft rubber catheter can be carried is, with its trocar, thrust through the liver tissue back of the tumor, the trocar withdrawn, and a rubber catheter threaded through the cannula. The catheter is tied or clamped on one side of the growth and another catheter is similarly placed on the other side of the growth and tied. They act as an elastic tourniquet. McDill compresses the vessels by an enterostomy clamp protected with rubber tubing, and others have recommended interlocking sutures of stout catgut placed around the tumor before it is excised. All sutures in the liver should be of stout material and tied no tighter than necessary to secure hemostasis, otherwise they will cut through. Occasionally the incisions can be made in such a way as to excise a tongue of liver tissue along the margins of the tumor, leaving two flaps to be approximated to each other by sutures. The incision is often made with an electric cautery to avoid hemorrhage. It must be remembered that the blood pressure in the liver is very low and firm pressure upon it by packing or by apposition of raw surfaces will control hemorrhage. Either a pedunculated graft or a free graft of omentum can be sutured to the bleeding surface of the liver and will often control the bleeding. If hemostasis is secured by the application of stomach or intestinal clamps and sutures will not hold satisfactorily, the clamps may be left in position for forty-eight hours and then removed.

Exposure of the contents of the upper abdomen, including the gall bladder and gall ducts, is satisfactorily accomplished by the Bevan incision, or its modifications. The vertical portion of the incision is carried down the inner portion of the rectus in order to preserve the nerve supply for a maximum amount of this muscle.

Removal of the gall bladder, or cholecystectomy, is an operation frequently performed. A satisfactory method of doing this is from below upward, and it is necessary to have an incision beginning just below the ensiform cartilage in order to obtain satisfactory exposure. The method as described by E. S. Judd is the technic that has been employed for many years and with much satisfaction at the Mayo clinic. The fundus of the gall bladder is clamped, preferably with a sponge-holding forceps, in order not to tear the tissues, and is pulled upward and forward until the pelvis of the gall bladder is exposed. The liver is brought up into the wound as far as possible and the surrounding tissues are protected by gauze packing. A second sponge-holding forceps is applied to the pelvis of the gall bladder just above the cystic duct. The tissues around the cystic duct are torn with forceps or incised with scissors and by blunt dissection, inserting closed scissors or forceps and spreading them open, the neck of the

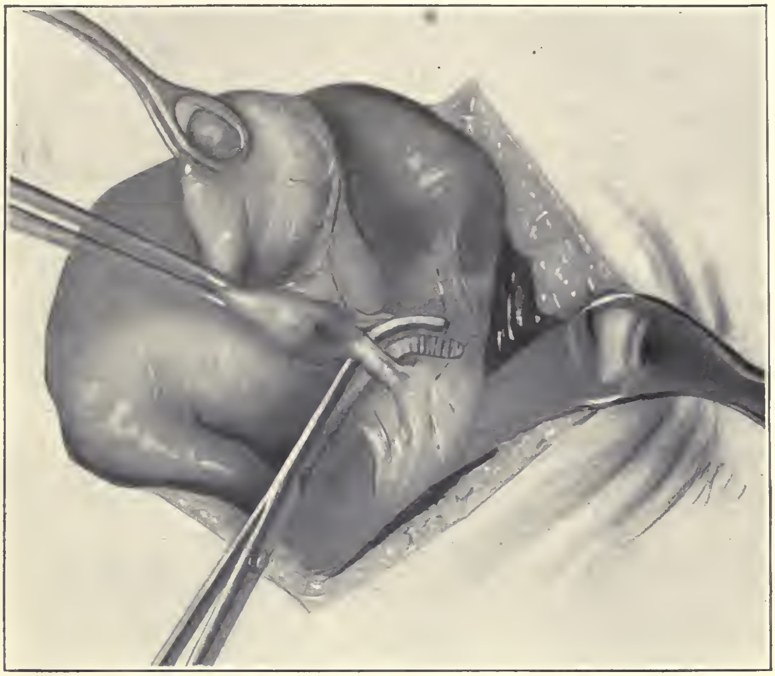

Fig. 483.—Exposure of the cystic duct in cholecystectomy.

Fig. 484.—Double ligation and clamping of the cystic duct.

gall bladder and the cystic duct are thoroughly exposed. It is important to demonstrate that the cystic duct runs into the gall bladder and to isolate it thoroughly by blunt dissection before it is clamped (Fig. 483). The cystic duct and the cystic artery may be clamped together or separately if they are not in immediate proximity as often happens. After the cystic duct is doubly clamped with a sufficient amount of the duct between the forceps to prevent retraction, the duct is divided. It is well to disinfect the stump of the cystic duct with a drop of carbolic on a probe, though this is not necessary. If exposure is difficult for double clamping, the cystic duct may be tied with tanned or chromic catgut close to the common duct and a clamp

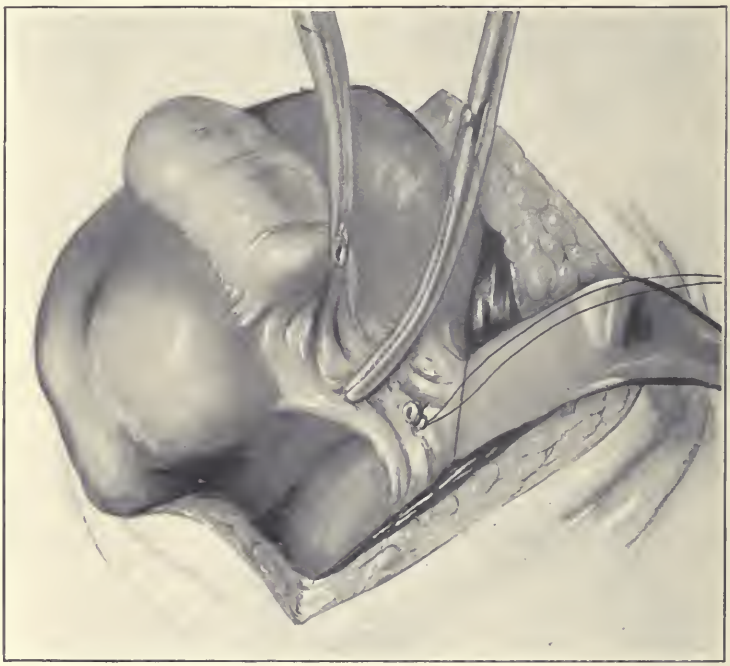

Fig. 485.—The cystic artery has been clamped and the gall bladder is dissected out from below upward.

placed on the neck of the gall bladder. Two ligatures are applied on the cystic duct stump at a short distance from each other. One is cut short and the other is left long and brought out in the wound (Fig. 484).

The severed cystic duct and the pelvis of the gall bladder are elevated by gentle traction and a forceps is applied behind and close to the gall bladder to grasp any vessels in this region. It is important on the one hand not to wound the gall bladder and so soil the field, and on the other to avoid injury to the hepatic duct. By making traction on the pelvis of the gall bladder and the severed cystic duct, the tissues can be brought into such prominence that they can be grasped with but little danger of injuring the gall bladder or the hepatic duct (Fig. 485). If an unusual vessel is divided or the cystic artery retracts, a small sponge of dry gauze in

forceps is pressed upon the bleeding spot. If it cannot be isolated satisfactorily a larger amount of dry gauze is held in position a few minutes and gradually removed along the edges of the raw surface until the bleeding vessel is located. The vessel is then grasped, preferably with small forceps, and is tied. Pressure with gauze will control the bleeding temporarily until the oozing has been checked, and then only the larger vessels will bleed. Indiscriminate catching of points in a bloody field in this region will almost certainly result in disaster and will cause the loss of more blood. A firm pack of dry gauze held in position for a few minutes and then care-

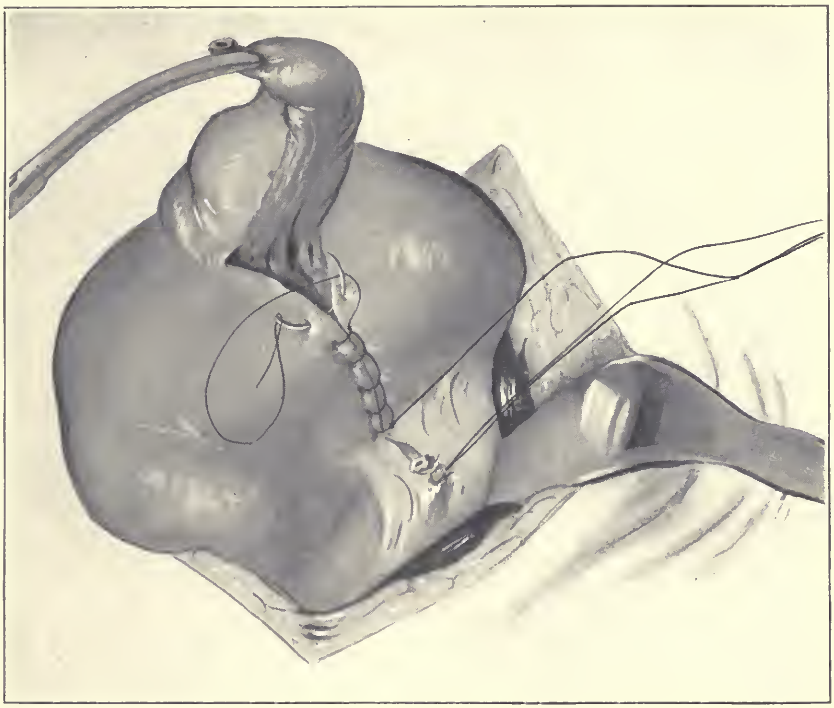

Fig. 486.—The cystic artery has been tied and the bed of the gall bladder is sutured.

fully removed from the margins of the wound until the main injured vessel is demonstrated will greatly aid in securing hemostasis in this region. Any bleeding more than a simple oozing should be thoroughly controlled before removing the rest of the gall bladder, for the gall bladder serves as a point of traction and renders the exposure of the field easier, while even a small amount of blood running down from the bed of the gall bladder makes it more difficult to locate bleeding points around the cystic duct. If the gall bladder is thick it can usually be dissected from the liver so as to leave a small amount of fascia in its bed which facilitates suturing the resulting raw surface. After removing the gall bladder and securing the cystic duct and artery the other bleeding points are controlled by transfixing the tissues immediately around them with a fine curved needle threaded with plain

catgut and tying the suture moderately firmly. The stump of the cystic duct, the common duct, and hepatic duct, should be well demonstrated to avoid possible injury to them.

The raw surface left by removal of the gall bladder is closed by suturing the tissues together with a continuous lock stitch of plain catgut, beginning at the lower portion of the wound and ending at the margin of the liver (Fig. 486). The suturing is just tight enough to control bleeding. The ends of this suture are tied at the margin of the liver and left long. A medium sized rubber tube is carried down to the stump of the cystic duct by cutting one hole near the end of the tube and passing the long ends of one of the ligatures over the stump of the cystic duct through the end of the tube and through this opening. The tube

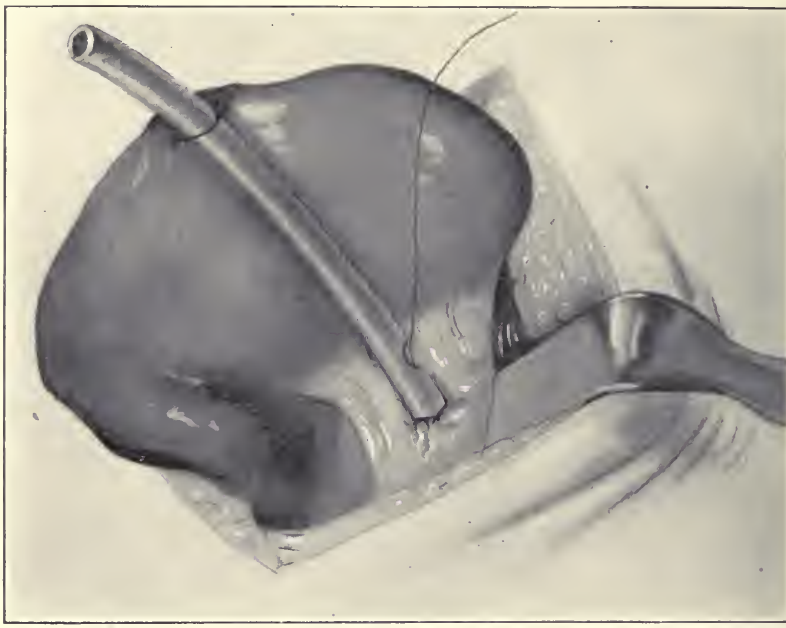

Fig. 487.—A rubber tube is carried to the stump of the cystic duct over the long end of the ligature and is fastened to the edge of the liver by the ends of the suture that closes the bed of the gall bladder. The suture line is behind the tube.

is further fixed in position by bringing it over the bed of the gall bladder and tying around it the long ends of the suture that had been used to whip over the bed of the gall bladder (Fig. 487). At the beginning of this suture the end should be left quite long and after the tube has been fixed in position, as has been described, fat from the edge of the omentum or from the round ligament of the liver, or from both, is brought down to the bottom of the tube and fixed in this position by a needle, into which has been threaded this long end which passes several times through the fat of the omentum or round ligament. Sometimes the fat of the round ligament is abundant and easily available. Occasionally the omentum is short and contains but little fat. Often both of these structures can be utilized. Care must be

taken to see that when the omentum is brought up the colon is not unduly constricted or kinked. This covering of the region of the tube with fat is important because it protects the duodenum and prevents it from being drawn up to the raw surface under the liver. In one case of mine after cholecystectomy in which this precaution was not taken, adhesions were dense between the duodenum and the liver and caused marked symptoms. In the second operation these adhesions were divided and a free graft of omentum was applied over the duodenum. There has been no recurrence of the symptoms, the operation having been done about five years ago. The wound is closed with silkworm-gut sutures, as has been described.

Murat Willis, of Richmond, buries the stump of the cystic duct and closes the wound without the insertion of a tube. This technic is satisfactory in the majority of cases, but occasionally the cystic duct will open even when securely tied with a double ligature and a small amount of bile will escape. This may not be due to an improper application of the ligature, but to the fact that nature makes unusual efforts to overcome obstruction of the bile ducts and pancreatic ducts and leakage may occur from necrosis where the suture was applied. Then, too, particularly in thin gall bladders it may be difficult or impossible to leave a sufficient amount of fascia in the bed of the gall bladder to hold the sutures. Here the sutures must be taken in the liver substance and occasionally injury of a small duct will cause leakage of bile. Leakage of bile that accumulates around a fresh wound is irritating and causes numerous adhesions and is best drained away. The tube also directs externally the current of serum or lymph that is poured out from the wound, whereas otherwise the exudate would accumulate about the cystic duct and probably infiltrate around the foramen of Winslow and the tissues in its neighborhood. While this serum might not be septic it causes considerable irritation. The tube is properly protected by fat. The fatty adhesions that result appear to give less trouble than the firm adhesions that follow the irritation of bile. Hertzler has pointed out that adhesions are denser along the periphery of a virulent inflammation than in its center, and that a marked irritation resulting from mechanical or chemical means or from a mild bacterial infection is followed by firmer adhesions than occur about the center of a virulent infection. This can be demonstrated clinically by finding adhesions to structures around an appendix that has been previously acutely inflamed while the appendix itself is free, or by seeing the scar of a duodenal perforation itself free from adhesions after healing has taken place with dense adhesions at points some distance from it.

The method of Murat Willis is excellent when no marked infection is present, or when a connective tissue bed is left after removing the gall bladder, and is particularly indicated when a cholecystectomy is done in conjunction with a pyloroplasty.

Cholecystotomy is now employed rather infrequently because in cholecystitis the infection is in the wall of the gall bladder, just as it is within the substance of the tonsil in tonsillitis, and drainage of the lumen of the

gall bladder often fails to cure. When, however, stones are contained in a gall bladder that appears fully to have recovered, or when there is marked infection and the condition of the patient makes it wise to do as little as possible, cholecystotomy is indicated. The gall bladder is exposed and after exploring the other structures to determine any pathology outside of the gall bladder the fundus is clamped, preferably with mosquito forceps or Allis forceps, and drawn into the wound. A trocar and cannula are thrust into the gall bladder and the bile is withdrawn. This may also be done by a large aspirating needle or the cannula may be connected with a suction apparatus. The opening made by the trocar and cannula is enlarged by thrusting in forceps or scissors and spreading the blades apart, or by an incision. The mucosa of the gall bladder is examined and the edges of the incision are grasped with three hemostats at about equal distance from each other. The rest of the bile is removed by gently inserting a strip of dry gauze. Any gall stones that are obvious are removed by a scoop or by forceps. After as many stones as possible have been removed in this manner the finger is inserted in the gall bladder and often imbedded stones may be found that cannot be otherwise detected. A tube about a third of an inch in diameter, of moderately firm rubber, and with one opening cut near its end is inserted. This is fixed in position by passing a fine tanned or chromic catgut suture through the margins of the gall bladder and the wall of the tube. This suture is tied and the ends are left long. A purse-string suture of fine tanned or chromic catgut in a fine needle is inserted. This is passed about half an inch from the margin of the gall bladder wound and as it is slowly tied down the raw edges are tucked in by an assistant, while the gall bladder is steadied by being grasped with forceps just beyond the purse-string suture. After the edges have been completely tucked in the suture is tied snugly three times and fastened with a needle to the parietal peritoneum to hold the gall bladder up. This prevents it from sagging and secures better drainage. The tube is brought out at the upper portion of the wound. There is no occasion for gauze packing around the tube, as such a junction is water tight under any reasonable pressure that may occur and the turned in margins of the gall bladder wound act as a valve. The tube is left in ten days or two weeks. In severe infection it should remain in longer. If it is difficult to remove the tube when it should be removed a large safety pin is passed through it near the skin and gauze is tucked under the safety pin so as to make gentle traction on the tube. This is repeated for two or three days, and the suture binding the tube gradually cuts through the tissue when the tube is removed with but little pain and no bleeding.

Operations upon the common bile duct are indicated on account of a contained stone or obstruction by a stricture. When stone is present the duct is incised over the site of the stone unless the stone is movable or is in an inaccessible portion of the duct. When the stone is movable the common

duct is opened just internal to the cystic duct and the stone is worked into this incision where it is extracted. The exposure should be ample and is afforded by the type of incision advised in operations on the gall bladder. The surrounding structures are well protected with gauze, particularly the foramen of Winslow. The gauze should be moist and is gently and carefully placed. Roughness in this region is very likely to cause shock or a reaction of protest by the tissues, which will later excite spasm of the upper abdominal muscles with consequent embarrassment of respiration and a tendency to congestion of the lung and pneumonia. Any fatty or loose tissue over the common duct is dissected away and the relation of the hepatic artery and portal vein to the common duct is borne in mind. The duct is opened with a longitudinal incision, which is extended if necessary either toward the liver or toward the duodenum. Often the duct in obstruction is greatly enlarged and the finger is readily admitted. If the finger can be introduced the hepatic ducts should be first explored and then the common duct. If dilatation is not sufficient for the finger the exploration may be made with a uterine sound, a small spoon-shaped curet, or with small forceps. After removing the stones a probe is introduced into the duodenum. It is sometimes difficult to ascertain whether the probe is in the duodenum or is merely pushing forward the ampulla of Vater. If a small spoon-shaped curet is used it can often be introduced into the duodenum and may withdraw duodenal contents.

After an incision in the common duct it should always be drained. This may be done by a T-shaped tube which is inserted into the incision and the wound in the common duct is slightly approximated by one or two sutures. An ordinary drainage tube, however, is usually satisfactory, and is cut with perforations at the end of the tube, or a triangular section is removed from the end of the tube so as not to obstruct the way from the hepatic duct to the distal portion of the common duct. A catheter with many perforations can often be inserted through the common duct into the duodenum or up toward the hepatic duct to drain the bile from the hepatic duct through the tube. Another method advocated by McArthur, and used with much success by Matas, is to insert a small rubber catheter through the opening of the common duct into the duodenum and to instill through this tube solutions such as salt solution or Locke's solution, which can be readily absorbed by the small intestine. This, of course, is only necessary in grave sepsis. A cigarette drainage is also carried down to the opening in the common duct. Halsted advises suturing the common duct and draining through the stump of the cystic duct, or, if impossible, through a small stab wound in the common duct. This is an excellent method.

Not infrequently such cases are accompanied by dense adhesions to the duodenum. In separating these adhesions the duodenum itself may be perforated or injured. If it is perforated the wound should be sutured, for a duodenal fistula is an undesirable thing at any time, but when it complicates stone in the common duct with jaundice it is exceedingly serious. If the duodenum has been injured the presence of the drainage tube will very likely

divert the flow of lymph toward the tube and away from the injured duodenum and this often results in a fistula. The presence of the tube, however, is entirely necessary for the recovery of the patient and when the duodenum is injured, after the perforation has been closed or even where the injury does not involve a perforation, omentum should be sutured over the injured duodenum. This is done by turning up a piece of the gastrocolic omentum or of the great omentum. Sometimes, however, the adhesions in such a case are so dense as to make this impracticable, and here a portion of the omentum is resected and applied as a free transplant to the injured duodenum, being fastened in position by interrupted sutures of chromic or tanned catgut. This graft will prevent the flow of lymph from the duodenum to the tube and actually calls for a larger deposit of lymph on the duodenum than would occur if the graft had not been placed.

Cholecystenterostomy may be indicated in chronic pancreatitis, in obstruction of the distal portion of the common duct, or in cancer of the head of the pancreas. The anastomosis is made between the gall bladder and the duodenum or the stomach. This does not provide as satisfactory drainage in inflammation as when a tube is inserted, particularly if a tube is placed in the common duct, because there is no occasion for any marked change in the lymphatic circulation, which is so frequently a prominent factor in the beneficial results of drainage. This operation, however, should relieve the pressure in the common duct and afford a satisfactory exit for the bile into the duodenum. In intense jaundice following malignant disease of the head of the pancreas it is a good palliative measure and in inflammation of the head of the pancreas, which is often difficult to distinguish from malignant disease, the operation will establish a permanent route for the bile which will relieve some of the factors that promote inflammation in the head of the pancreas.

The operation, as usually performed, consists in making a longitudinal incision into the duodenum and anastomosing this incision with an opening in the gall bladder. A longitudinal incision splits the longitudinal muscular fibers of the duodenum, which are external, and favors the closure of the opening, as each time the longitudinal fibers contract they narrow the anastomotic opening into the bowel. To avoid this the incision in the duodenum should be transverse instead of longitudinal. After exposing the duodenum and gall bladder through an ample incision a portion of the fundus of the gall bladder that can be placed in contact with the duodenum without too much tension is selected and the place for the incision on the duodenum and on the gall bladder is marked by being grasped with Allis forceps. If necessary the duodenum is slightly mobilized by carefully incising the peritoneum along its outer border. A fold of duodenum caught transversely is fixed with forceps used for lateral blood vessel suturing. The forceps have delicate springs and blades and cannot injure the bowel wall. There is no occasion for protecting these blades with rubber tubes (Fig. 488). The gall bladder is grasped by another pair of forceps after stripping back the bile.

Gauze packing is placed beneath the gall bladder, and the surrounding tissues are protected with gauze. The posterior part of the clamped portion of duodenum is sutured to the posterior part of the clamped portion of the gall bladder with a small curved needle carrying fine tanned catgut as in the preliminary step for gastroenterostomy. After this row has been completed the ends of the suture are clamped and used as tractor sutures. This avoids undue manipulation of the clamping forceps which may easily be displaced. The clamped portions of the duodenum and gall bladder are incised for an inch or more and gently mopped with moist gauze. The duodenum is cut transversely as it is clamped. A continuous lock stitch unites the cut edges along the posterior margin (Fig. 489). This suture may be of

Fig. 488.—The author's method of cholecystenterostomy. The duodenum is clamped at a right angle to its axis with the soft bladed forceps used for lateral blood vessel suturing.

tanned or chromic catgut, or if the patient is old and tissue healing is likely to be poor, especially in cancer of the pancreas, the suture material had best be silk or linen. This inner row is begun at either the upper or the lower angle of the wound. After completing the suturing of the posterior margins of the wound the same suture is continued along the anterior margins. It is here converted into a right angle stitch penetrating the whole wall, or, if the tissues are vascular, it is placed throughout as a continuous lock stitch bringing the edges of the wound snugly together to avoid the possibility of hemorrhage. When the point of beginning is reached the suture is tied to the long end left at the first knot of this row of sutures. Three or more knots are snugly tied and the ends are cut short. The original line of sutures is then continued as a right angle continuous stitch, ap-

proximating as broad a surface as can be brought together without tension. When this row is completed the thread is tied to the end of the original knot of this line of sutures. As the greatest point of tension is at the ends of the incision, an additional mattress suture is placed at these points. The wound is closed without drainage. If this suturing is properly done the anastomosis should heal satisfactorily, even in cancer cases with low nutrition, but if drainage is placed it may cause a breaking down of the suture line.

If the duodenum is inaccessible the anastomosis may be made with the nearest portion of the stomach with almost as good clinical results. The

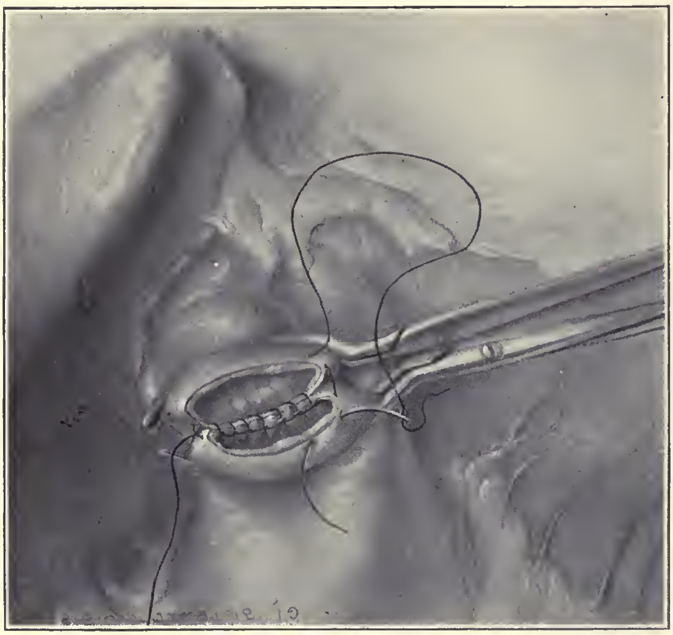

Fig. 489.—The gall bladder is similarly clamped and a row of sutures unites the gall bladder to the duodenum. The gall bladder and duodenum are then incised and a second row of sutures, uniting the margins of the wound, is placed.

colon should never be used because of the probability of infection of the bile tract from the colon.

Reconstruction of the common duct may be indicated as a result of stricture from long continued inflammation or from the passage of stones, or because of injury during a surgical operation. In such instances the bile usually flows through an external fistula and often there is also inflammation of the bile tracts with chills and fever. Numerous efforts have been made to reconstruct the common bile duct by grafting or by transplantation of tissue. Grafts of fascia or inverted veins or similar material have proved unsatisfactory. While they may appear to give good results at first, any tissue which is foreign or which has no biologic resistance to bile will react profoundly. There will be dense leucocytic infiltration which is followed later

by cicatricial contraction and obliteration of the reconstructed duct. The reconstructed duct closes first at its extremities where the combination of the sutured end and its wall furnishes a maximum contact with the bile and where, consequently, the reaction to the bile would be greatest. In reconstruction of the bile ducts, of the intestines, or of any hollow viscera, whose contents may irritate other tissues, only tissues should be used which have a biologic resistance to the normal contents of the duct or viscera to be repaired. A sutured intestine, for instance, will heal satisfactorily if the raw edges are inverted and the peritoneum is accurately approximated, though the fecal current is constantly passing over the cut raw edges of the bowel which have been turned into its lumen. If, however, we were to keep a wound in the skin bathed with fecal matter, as the inner portion of the intestinal wound is, we would expect a violent reaction and if healing ever occurred it would be with a pronounced scar. This is because the walls of the intestine have a certain biologic resistance against the irritating effects of the contents of the bowel. This resistance is perfect in the intact mucosa but exists to some extent in the deeper layers of the intestine. The study of a segment of transplanted vein used in reconstruction of the common bile duct brought these facts vividly to mind.[1]

The method of A. G. Sullivan in which a rubber tube is sutured into the hepatic end of the common duct, carried into the duodenum, and surrounded by neighboring tissues and the omentum is much more satisfactory than the reconstruction of the common duct by fascia, because the tissues in the neighborhood of the bile tracts and the omentum have more biologic resistance to the irritating action of bile than fascia transplanted from a distant part.

The obvious deduction is that in reconstructing the bile ducts tissues that are accustomed to the presence of bile should be used and should include not merely the epithelial lining but the submucosa. The constriction does not take place in the epithelial lining, but in the submucosa which corresponds to the corium or derma of the skin. Even though a tube of fascia by which the common duct is reconstructed may be lined with epithelium, the fascia itself reacts to the irritating effect of the bile and sooner or later complete occlusion occurs. To prevent eventual occlusion, then, it is necessary not only to have an epithelial-covered surface but a submucosa with biologic resistance to the irritation of bile. This means that the mucosa and submucosa of the bile tracts and the duodenum must be used wherever possible.

W. J. Mayo[2] has frequently operated by bringing the duodenum to the hepatic end of the stump of the common or hepatic duct and suturing it in this position. The duodenum is mobilized and the stump of the duct to be united is fastened to the posterior edge of a short incision in the duodenum by a few interrupted sutures. Other sutures are placed so as to unite more

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[1]Horsley, J. Shelton: Reconstruction of the Common Bile Duct, Jour. Am. Med. Assn., Oct. 12, 1918.

[2]Collected Papers of the Mayo Clinic, 1915, p. 274.

accurately the mucosa of the duct to that of the duodenum. Then a rubber tube is placed of such a caliber that it fits not too snugly into the duct, reaching about an inch into the hepatic portion of the duct and a similar distance into the duodenum. It is fastened in position with a catgut suture which is absorbed after a few days and permits the tube to be expelled. The rest of the wound is closed by layers of interrupted tanned or chromic catgut sutures and the omentum is brought over the whole wound and fastened in position with sutures.

LeGrand Guerry,[3] of Columbia, S. C., has utilized this principle in a number of cases. When there is a fistula present a probe is inserted through the fistulous tract to the bile duct. It is best to dissect outside of this fistula as far as possible until the duodenum has been exposed and the upper end of the bile duct recognized by the end of the probe. The tract is then cut through near its internal termination and the hepatic stump of the duct is demonstrated. He mobilizes the duodenum as much as possible and incises it down to the mucosa. The mucosa protrudes and gives an additional amount of tissue which is more readily mobilized than the whole thickness of the duodenum. A tube is inserted and sutured in a similar manner to the method of W. J. Mayo. If the closure has been satisfactory and the wound well surrounded by omentum drainage is unnecessary as it may predispose to the breaking down of the sutures.

In ascites, due to cirrhosis of the liver, operations have been devised for side tracking the blood and so relieving the tension in the portal circulation. In cirrhosis of the liver all cases of ascites are probably not due solely to the increased tension in the portal circulation, as there may be other factors. A diminution of the portal pressure, however, is often followed by decrease in the ascites. Eck's fistula was supposed to relieve this condition by establishing a communication between the portal vein and the vena cava. This has not proved satisfactory in man because the large amount of metabolic products that are contained in the portal circulation are transferred directly to the general circulation. These products should first go through the liver, where they are changed by the liver into nutritive or innocuous material. Unless the liver intervenes, they become deleterious when introduced directly into the circulation. A small part of these products, however, can be taken care of by the general circulation without serious effect. The operation of Talma produces an anastomosis between the vessels of the portal circulation and those of the general circulation and so relieves portal pressure without admitting to the general circulation more than a small portion of the material absorbed from the intestines. This operation, known as omentopexy, which was devised independently by Rutherford Morison and by Talma, is sometimes satisfactory in ascites due to cirrhosis of the liver. The abdomen is opened to the right of the midline above the umbilicus and all the ascitic fluid is evacuated. With dry gauze the upper surface of the

[3]Guerry, LeGrand: Jour. Am. Med. Assn., Oct. 12, 1918.

liver is rubbed to form adhesions between the liver and the diaphragm. The spleen is similarly treated. The omentum is then pulled into the wound and united to the anterior parietal peritoneum and the margins of the wound. Usually there has been much distention with the ascites and after the fluid has been evacuated the abdominal wall can be everted to expose a considerable area of the parietal peritoneum. The omentum is sutured around the wound as far from the incision as possible, particularly far over on the left side. After both sides are sutured the wound is closed with interrupted sutures of silkworm-gut. A muscle splitting incision is made after the manner of McBurney in the right iliac fossa and a tube is inserted to drain off the fluid in the pelvis. This is necessary, for the fluid if allowed to accumulate before the anastomosis of the small vessels has formed, will interfere with the union of the omentum to the peritoneum. This operation can often be done under a local anesthetic.

The Mayos have modified this method by making one incision on the right side over the liver as near the deep epigastric and internal mammary vessels as possible and a second incision four inches below this through the rectus muscle, but not through its posterior sheath. After separating the muscle from its posterior sheath extensively, a portion of the omentum is drawn through the upper part of the incision and pulled down into the pocket where it is fixed in position with a few sutures. A similar procedure can be carried out on the left side and the intervening segment of omentum may be united to the parietal peritoneum. These operations done in the early stage afford much comfort and relief from ascites, but, of course, they are not curative of the cirrhosis.

In tumors of the head of the pancreas or the duodenum it may be necessary to transplant the end of the common duct in order to resect the head of the pancreas. Coffey has worked out a technic for this operation by transplanting the end of the duct into the duodenum obliquely, first incising the duodenum for about an inch down to the mucosa, then puncturing the mucosa at the end of the incision distal from the duct and fastening the duct at this point with a few sutures. The wound is then closed in such a manner that the duct rests in the length of the incision solely on the mucosa and the submucosa, the muscular and peritoneal coats being closed over it. In this manner the mucosa acts as a valve and prevents back pressure into the duct.

Operations on the pancreas are chiefly for relief of pancreatitis. Cancer of the head of the pancreas is usually inoperable and though Finney has successfully extirpated a growth involving the middle of the pancreas, cancer is more frequent in the head than in any other portion of this organ. The operation to meet the indications for excision of cancer of the pancreas should be arranged for excision of the head of the pancreas. Coffey[4] has worked out experimentally on dogs a very ingenious technic for this excision, though the operation has not yet been tried by him on man. It

[4]Coffey: Ann. Surg., December, 1909.

consists first of extirpation of the duodenum with the head of the pancreas and the adjoining tissues, including the end of the common duct. This would be the type of operation indicated in cancer. The pancreas is excised at a sufficient distance from the malignant growth. The central vessels are tied. The pancreatic duct is divided so that half an inch or more of the duct is left protruding from the raw surface of the cut pancreas. A loop of jejunum is then brought up and sutured together along its convex border as though a lateral anastomosis would be made. The bowel is incised in such a way as to throw the lumens of both ends together (Fig. 490). This makes the combined capacity of the two limbs of the loop sufficient to contain the stump of the pancreas without too much

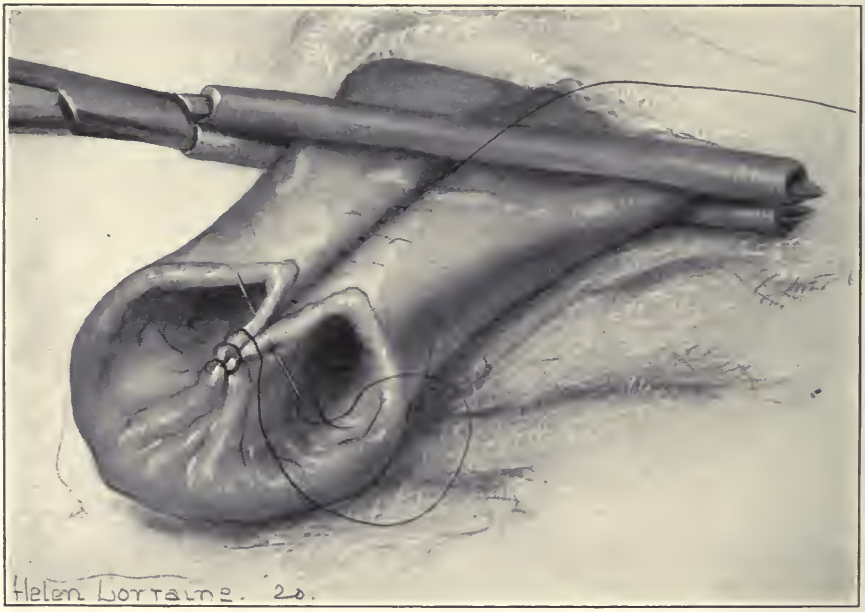

Fig. 490.—Excision of the head of the pancreas. A loop of jejunum is clamped, opened, and sutured in the manner indicated to throw the lumens of both loops into a common opening (Coffey).

tension. The peritoneal surface at the end of the loop is inverted by mattress sutures which grasp the end of the bowel and are inserted further down in the lumen so that when pulled upon the end of the combined loop is inverted. The stump of the pancreas is placed within this prepared receptacle made from the combined loops of the jejunum. Sutures are taken at some distance from the end of the stump of the pancreas and fasten the pancreas to the edge of the opening of this loop. The end of the bowel is snugly approximated to the pancreas by a collar suture which buries the other sutures that have been taken from the pancreas to the bowel (Fig. 491). In this manner a considerable portion of the pancreatic stump is covered. The end of the common duct is implanted obliquely into the adjoining distal stump of the duodenum by making an incision of an inch down to the mucosa (Fig. 492),

puncturing the mucosa at the most distal point from the common duct, and after splitting the common duct for a short distance its tip is inserted into this puncture and held by a suture which passes through the wall of

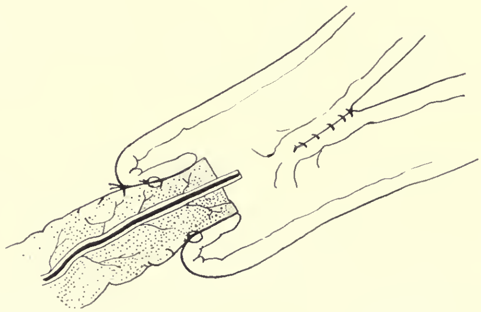

Fig. 491.—Diagram showing the head of the pancreas excised and the stump of the pancreas implanted into the loop of jejunum which has been prepared as shown in Fig. 490 (Coffey).

Fig. 492.—The common bile duct is transplanted into the duodenum or into another loop of jejunum. An incision is made down to the mucosa, which is punctured at the end of the incision farthest from the common duct (Coffey).

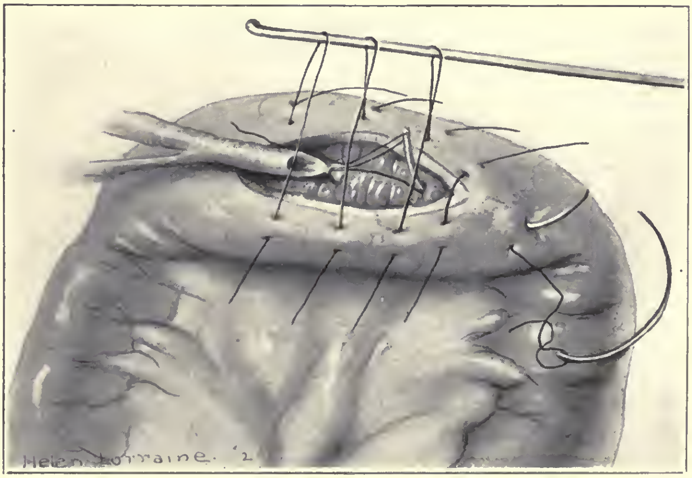

Fig. 493.—The tip of the common duct is drawn through the puncture of the mucosa as indicated in the drawing (Coffey).

the duodenum (Fig. 493). The rest of the wound is closed by intestinal sutures so that the duct is partially protected from the intraintestinal pressure by the valve of mucosa (Figs. 494 and 495). A gastroenterostomy is done in the usual manner.

Operations for pancreatitis vary according to the stage of the pancreatitis. In acute conditions, where the pancreas is greatly swollen, short incisions are made into the pancreas to relieve tension and are enlarged by inserting closed forceps and spreading the jaws. Drainage with tubes and gauze is

Fig. 494.—The transplantation of the common duct is complete (Coffey).

carried down to the wound in the pancreas. If there is free oozing the supply of gauze drainage should be abundant. The approach to the pancreas is usually best made through the gastrocolic omentum. If the stomach is prolapsed the pancreas may be approached above the lesser curvature of the stomach. The necessity for incision in the pancreas must be decided by the

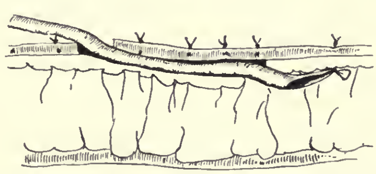

Fig. 495.—A sectional view of the transplanted duct, showing how the mucosa acts as a valve to prevent back pressure when the bowel is distended (Coffey).

character of the inflammation. In subacute or in chronic pancreatitis it is not necessary to make incisions in the pancreas, but drainage should be established either through the gall bladder or the common duct. This relieves the pressure in the common duct and prevents to some extent the reflux of bile into the pancreatic duct which has been shown by Opie and others to be a very important factor in the causation of many cases of pancreatitis. The drainage tube in the common duct or the gall bladder probably also acts as has been indicated in the chapter on Surgical Drainage by reversing the lymphatic circulation and diverting it toward the drainage tube in an effort to extrude

the foreign substance, which is the tube. This may divert the lymphatic flow from the pancreas and so cause a withdrawal of some of the septic products of inflammation.

A pancreatic cyst may arise at any portion of the pancreas and when large sometimes points below the colon and may simulate a tumor of the lower abdomen. It is usually best treated by marsupialization. An incision is made over the most prominent part of the growth and the relation of the cyst to the mesentery of the intestine and to the surrounding viscera is carefully noted. An area of the cyst that approximates the abdominal wall is selected and the structures over it are displaced in such a manner that they will be the least disturbed. Frequently the cyst can be approached through the gastrocolic omentum. The peritoneum of this omentum is split and the cyst either sutured to the parietal peritoneum or packed around with gauze for four or five days until adhesions have formed. A cyst often forms as a result of pancreatitis and is sometimes hemorrhagic. If a large hemorrhagic cyst is emptied suddenly there may be hyperemia and further bleeding which may necessitate packing the cyst. This can best be avoided by emptying the cyst gradually if its contents have been proved by diagnostic aspiration to be bloody. The fact that pancreatitis is apparently often caused by inflammatory disease of the bile tracts makes it advisable to explore the gall bladder and bile ducts. If any lesion is found the gall bladder or the common duct is opened and drained. This relieves the pressure within the common duct and prevents the flooding of the pancreas with bile, which is often the cause of pancreatitis.

Surgery of the spleen consists largely in splenectomy. Occasionally a wandering spleen is fixed in position, which may be best done by the method of Bardenheuer, by making a pocket in the parietal peritoneum and inserting the lower portion of the spleen into this pocket. The spleen is further fixed by passing one stout suture through the lower end of the spleen and tying it around the tenth rib. As a rule, when the spleen is sufficiently movable to cause trouble an excision is the most satisfactory procedure.

The technic of removal of the spleen depends largely upon its size. Ample exposure is always necessary. The incision of Bevan, which has been described, is used on the left side and the gall bladder and liver are first thoroughly explored. If the spleen is not greatly enlarged and is nonadherent it is turned into the wound and the pedicle secured from behind. If the spleen is large and adherent the operation may be exceedingly difficult. Balfour[5] emphasizes the following points in splenectomy: (1) The abdominal exploration; (2) the dislocation of the spleen; (3) the use of hot gauze packs; (4) the protection of the stomach and pancreas from injury; (5) the preliminary ligation of adhesions; and (6) the treatment of the pedicle of the spleen. The first step of the operation after exploration consists in mobilizing the spleen by thoroughly separating the adhesions between the surface of the spleen and the parietal peritoneum. If the

[5]Balfour: Surg., Gynec. & Obst., 1916, xxiii, 1-6.

adhesions cannot be stripped satisfactorily they should be doubly clamped and divided. If there are many adhesions between the spleen and the diaphragm these may be separated by the finger or if they are large and vascular they should be doubly clamped and divided. The spleen is dislocated inward and a large pack of gauze wrung out of hot salt solution is quickly inserted into the cavity formerly occupied by the spleen. This step, according to Balfour,

Fig. 496.—Exposure of the pedicle of the spleen in splenectomy. The splenic artery has been doubly tied (Balfour).

is very important and serves not only to control bleeding, but acts as a support from which point the spleen may be more readily handled. This pack is not disturbed until after the completion of the operation. The main pedicle of the spleen is then brought into view from its posterior surface. It must be borne in mind that the splenic veins are exceedingly friable and may be readily injured. The dissection of the pedicle is made as close to the spleen as possible, so that bleeding from an injured vein can be more readily located. The gastrosplenic attachment should be divided in sections as close to the spleen

as possible, the division being made between ligatures. The vasa brevia are the chief vessels here. The spleen is often closely attached to the stomach and there is the danger of injuring the stomach if clamps are placed promiscuously in this region. By doubly ligating this portion of the pedicle and then dividing between ligatures this accident may be avoided. The exact relation of the stomach is ascertained before placing the ligatures. Careful dissection of any retaining peritoneal bands or fibers is made so as further to mobilize the spleen, always bearing in mind the very friable nature of the splenic veins. The tail of the pancreas must be recognized. Its position is often very irregular. It

Fig. 497.—Another method of treating the pedicle of the spleen when it is difficult to expose the splenic artery (Balfour).

may actually be adherent to the hilus of the spleen, or it may be at such a distance that it is safely out of range of injury. Sometimes, according to Balfour, the tail of the pancreas lies behind the renal surface of the spleen and sometimes it fits so closely into the hilus of the spleen as to have acquired a concave edge; or it may be in front of the splenic vessels in contact with the stomach. After locating the tail of the pancreas it should, of course, be dissected from the spleen and the pedicle with great care. The treatment of the main pedicle that is left after separating the upper portion of the spleen

from the stomach depends largely upon the location and the arrangement of the vessels. If the splenic artery can be readily demonstrated it is ligated before the veins are tied (Fig. 496). If, however, this is impracticable, the spleen is clamped by three pedicle forceps at distances of about half an inch apart and the pedicle is cut between the two forceps nearest the spleen (Fig. 497). A ligature of catgut is applied to the pedicle after removing the forceps farthest from the spleen. This ligature is placed in the crushed line left after removing the clamp. A second ligature of similar material transfixes the pedicle just below the distal clamp and is tightened as this clamp is removed. The gauze packing is then carefully withdrawn and any bleeding spots that are left are grasped with forceps and whipped over with catgut in a small round needle. If there is a considerable oozing surface that cannot be readily controlled the packing may be left in position.

W. J. Mayo makes a practice of closing the abdomen with the packing in position in the cases in which the bleeding surface is extensive, venous in character and difficult to control except by packing. The sutures in the abdominal wall are through-and-through sutures and are tied in a bow knot. Two or three days later the sutures are untied, the packing is carefully removed, and the abdominal wall is closed permanently with the sutures that were originally tied in a bow knot. This method seems to lessen the danger of infection which is considerable when a large amount of gauze is left in position with the ends of the gauze protruding through the wound.

CHAPTER XXV

OPERATIONS ON THE STOMACH

Operations on the stomach may be for correction of displacements or deformities of the stomach or for the cure of ulcer or malignant disease. Operations for displacement or ptosis are often done in connection with ptosis of other organs, such as the colon. The indications for suturing the stomach in position must be distinct. Often a prolapsed stomach will empty satisfactorily, but when it does not, and particularly when accompanied by marked ptosis of the colon and when roentgenographic examination shows a much delayed emptying of both organs, operation may be indicated. Many operations have been devised to correct this condition. Suturing the stomach to the abdominal wall by various methods has been practiced. The hammock operation of Coffey, while really devised for ptosis of the colon, lifts the stomach upward and forward. In Coffey's hammock operation the gastrocolic omentum is sutured to the parietal peritoneum by a series of interrupted sutures in a transverse line as far above the umbilicus as the sutures can be conveniently placed. This usually is about half way between the ensiform cartilage and the umbilicus. The chief objection to this procedure is postoperative pain from pulling on the parietal peritoneum though it seems far better than fixing the stomach wall to the parietal peritoneum, or any of the methods of gastroplication formerly advocated. In the hammock operation the stomach is permitted a considerable amount of freedom as it is suspended from what is really one of its ligaments and the mobility of its wall is but little affected. The pain following this operation, however, is not only severe but often embarrasses respiration. While the pain either completely or in a large part disappears in the course of time it is an annoying symptom for at least a few days after operation and sometimes for many weeks.

When the natural anatomical tissues that are intended for suspension of organs can be utilized the effect is more nearly to reproduce normal physiologic function than if an unnatural suspension or fixation is performed. The main ligament that holds the stomach in position is the gastrohepatic omentum. This has been utilized by Beyea, whose operation of gastropexy consists in taking a reef in the gastrohepatic omentum by several rows of sutures. The great objection to this is that the central part of the gastrohepatic omentum is the weakest and yet it is usually opposite this central portion that the ptosis of the stomach is most pronounced. Sutures at this point where the structures are weakest have the greatest strain to bear. Then, too, the insertion of a series of sutures sufficiently high under the liver is not always an easy task if they are placed carefully to avoid blood vessels.

I have slightly modified the Beyea method by using a single pursestring suture of linen or silk, placed with a small curved needle. This is begun on the lesser curvature of the stomach on the left side of the midline, at the apparent point of beginning of ptosis where a firm bite is taken in the gastrohepatic omentum just as it enters the stomach. Care is taken to avoid the vessels. The second bite of the needle is in the gastrohepatic omentum at a point vertically above the first bite, well up under the liver and in the thicker tissues in the left of the midline, avoiding the large vessels.

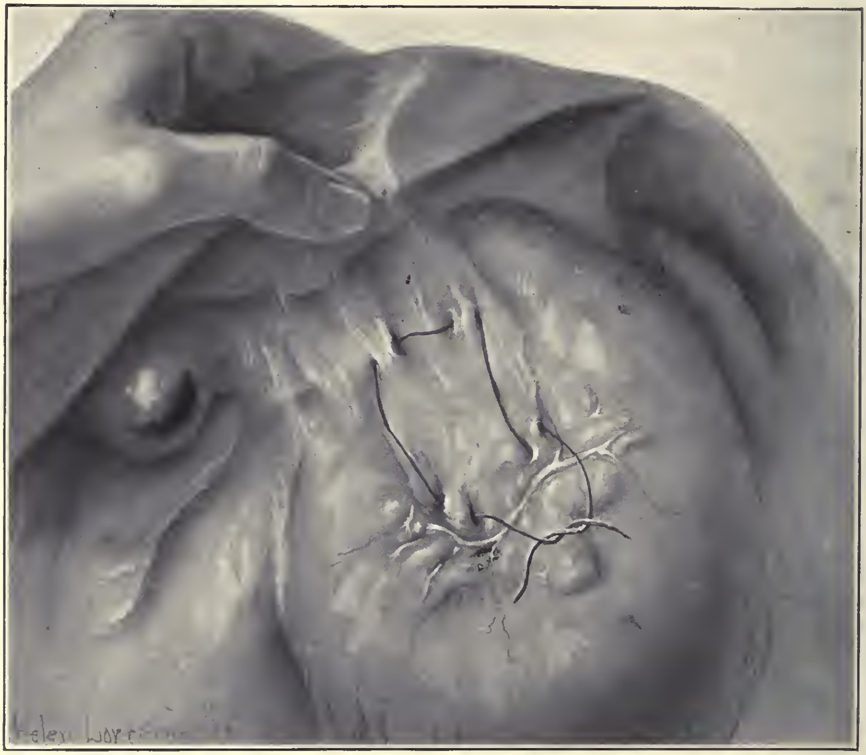

Fig. 498.—Shortening the gastrohepatic omentum in ptosis of the stomach.

Often this operation is undertaken in very thin individuals and in order to grasp satisfactory tissue it will be necessary to insert the needle near some large vessel where the firmer connective tissue forms a support to the larger vessels. This can be done so long as the vessel can be demonstrated and is not injured by the needle. The suture is then carried across the midline to the right side and catches a bite in the gastrohepatic omentum high up under the liver. The fourth bite is taken in the gastrohepatic omentum near the pylorus, vertically below the third bite and on the right side of the midline. It should grasp the omentum just as it enters the stomach (Fig. 498). The stomach is pushed well up under the liver and the suture is gradually tightened. This must be done gently to prevent the delicate tissues from tearing.

The knot is tied three times and the ends are cut short. Usually there is also a prolapse of the transverse colon. If so the colon is brought up in position by a series of sutures of linen or silk, which take a reef in the gastrocolic omentum by beginning on the left side and going from the omentum

Fig. 499.—The gastrohepatic omentum is shortened and sutures are placed in the gastrocolic omentum.

just as it leaves the stomach to the omentum just as it reaches the colon. In this manner the colon can be brought up rather snugly to the stomach (Figs. 499 and 500). It is important to put the patient to bed with the foot of the bed slightly elevated. Feeding through the stomach should not be begun for about three days after the operation and then it should be in small amounts, though an ounce of water can be given every hour. Small rectal enemas, not more than three or four ounces, are given every six or eight hours.

This operation has been very satisfactory. According to Coffey the peritoneum is one of the most satisfactory means of holding displaced organs in position and his operation for retroversion of the uterus was founded on this principle, which he has thoroughly demonstrated. If too great strain is not placed upon the stomach until the sutured omentum has had an opportunity to repair the prolapsed viscera will in all probability remain in their replaced positions. This gives the stomach and colon the advantage of normal anatomical support and their physiology should be much less interfered with by such a procedure than by introducing abnormal ligaments or by fixing the stomach wall to the abdominal wall so that it is impossible for the stomach to have its physiologic peristaltic waves.

Fig. 500.—The sutures in the gastrocolic omentum are placed and tied.

In relaxation of the abdominal wall, when accompanied by ptosis, support is often satisfactorily given by the proper closure of an incision from the level of the umbilicus to the pubis. It is made a little to the right of the midline. After doing whatever intraabdoinmal work is necessary the peritoneum is closed by a continuous mattress suture that approximates the transversalis fascia and peritoneum on one side to like structures on the other. The sheath of the rectus muscle on the left side is opened and the recti muscles are sutured together by a continuous lock stitch of stout plain catgut. The anterior sheath of both recti muscles, which consists of aponeurosis of the flat muscles, is undermined on both sides for a space of about three inches. The fat is dissected from the front of the fascia and the left edge is folded under the right edge

for about three inches and fastened by a series of mattress sutures of tanned or chromic catgut in a similar manner to that described in repair of umbilical hernia. These sutures are all inserted before any one is tied. They are all drawn taut and held by an assistant, while one is tied at a time. A flap, which consists of the right portion of the anterior part of the sheath of the recti muscles is overlapped on the left side and fastened by suturing its edge to the surface of the aponeurosis with a continuous lock stitch of tanned or chromic catgut.

Coffey recommends taking up the slack in the relaxed abdominal wall by making a long incision in the general direction of the McBurney incision first on the right and then on the left. The aponeurosis of the external oblique is split and overlapped in the manner just described for overlapping in the midline.

A common cause of gastric surgery is ulcer and this is frequently found at the pyloric end of the stomach. There are many types of operations done for the relief of gastric ulcer, but the most common operation for this disease is gastroenterostomy, with or without excision of the ulcer. The late results of gastroenterostomy, however, leave much to be desired. Frank Smithies,[1] a gastroenterologist, has reported 273 patients on whom this operation had been done. His paper was intended as a study of the function of the stomach after gastroenterostomy, but the sidelights on the efficiency of this operation as a therapeutic measure are illuminating.

Smithies' 273 cases represent 226 patients operated on for gastric or pyloric ulcer, twelve for gastric cancer, and thirty-five for duodenal ulcer not involving the pylorus. Of this entire number, he reports only fifty-seven, or 20.9 per cent, clinically complaint free. Twenty-eight of the thirty-five duodenal ulcer patients had pain or distress, and many of this number had other symptoms, such as gas, nausea, vomiting, or eructation. As the total number of cases, however, is made up of (1) patients requested to return for examination regardless of their condition, and (2) patients who came voluntarily because they were having trouble, the percentage of cures represented is too low. In reply to a request, Smithies has written me under date of April 10, 1919, that about 65 per cent of 273 patients (177) returned for examination at his request. Percentage based on this number (177) would be unduly favorable because these cases were selected apparently arbitrarily from a large number of stomach patients on whom operation had been performed and who had been observed by Smithies (2,360) and would not include those patients who came voluntarily because of trouble. Making all allowances for this latter group, which constitutes about one-third of the total number, we still have a percentage of complaint free patients that is very low (much below 50 per cent) both for gastric and for duodenal ulcer patients on whom gastroenterostomy had been done.

Balfour[2] says that although surgery gives permanent relief in a higher percentage of cases of gastric ulcer with less risk than any other therapeutic

[1]Smithies, Frank: Surg., Gynec. & Obst., March, 1918, xxvi, p. 275, et seq.
[2]Balfour: Surg., Gynec. & Obst., xxiv, p. 731, et seq.

measure, surgical treatment of gastric ulcer may be made more efficient. He reports 285 cases of gastric ulcer that have been operated upon at the Mayo Clinic with 55.7 per cent complaint free cases. The rest are classified as "greatly improved," "improved," and "unimproved." These results reported by Balfour and by Smithies certainly cannot be considered satisfactory so far as curing the patients is concerned.

It is obvious that gastroenterostomy for duodenal or gastric ulcer does not restore the stomach to its normal physiologic condition. The clinical cures following this operation have been variously explained. Some have said that it is a gravity drainage operation, and yet in draining other hollow muscular viscera we do not open at the lowest point. The gall bladder and the urinary bladder are drained from the part opposite the most dependent portion, and an enterostomy is done on the loop of intestine nearest the obstruction and not on the loop deepest in the pelvis; for we know that normal contraction or peristalsis will keep the bladder or bowel empty if an opening is made. From time immemorial the current of pressure and the peristaltic rhythm of the stomach have been focused on the pylorus, and not on the so-called lowest point in the stomach. Besides, there is no one portion of a mobile muscular organ, such as the stomach, that is always the lowest point. This and other disadvantages of gastroenterostomy have been admirably demonstrated by Cannon and Blake.[3] It has been affirmed that gastroenterostomy cures by short-circuiting the course of food and so resting the ulcer; and also that it cures by lessening the acidity of the gastric juice. The roentgen ray has shown that unless the pylorus is closed some food usually continues to go by this route and pyloric closure is not often permanent unless a resection is done.

Lennander's statement[4] that the stomach is without sensory nerve supply for pain has been apparently disproved. Other investigations[5] seem to have shown that the stomach has a limited supply of nerves that conduct pain. These nerves terminate in the muscular coat of the stomach, and do not reach the mucosa. The pains that come on with such clocklike regularity after meals in duodenal or gastric ulcer are not caused by acid erosion of the ulcer by the hyperacid gastric juice, as was formerly believed, but are due to the pressure of peristalsis on these gastric nerves, which are made unusually sensitive by the inflammation of the ulcer. Consequently, they register impulses of pain from the pressure of peristalsis which in a normal physiologic condition they would not register. The gastric juice has nothing to do with the pain except so far as it excites peristalsis.

Gastroenterostomy probably relieves the pain from a duodenal or gastric ulcer by facilitating the emptying of the stomach and thus lessening peristalsis. It is also probable, as has been claimed by others, that a certain

[3]Cannon and Blake: Ann. Surg., May, 1905, xli, 686-711.
[4]Lennander, K. G.: Jour. Am. Med. Assn., Sept. 7, 1907, xlix, 836.
[5]Kast, L., and Meltzer, S. J.: Sensibility of Abdominal Organs and the Influence on It of Injections of Cocain, Med. Rec., New York, December, 1906, lxx, 1017. Ritter, C.: Sensibilität der Bauchorgane, Zentralbl. f. Chir., May 16, 1908, xxxv, 609.

amount of jejunal contents regurgitates into the stomach and decreases the acidity of the gastric juice. This affects the pain, however, by diminishing the peristalsis because, as has been explained, the bad effect of a hyperacid gastric juice on an ulcer is not due to any intrinsic action of the gastric juice because of acidity, but it is because the excessive acidity stimulates the peristalsis and excessive peristalsis not only produces pain but prevents healing of the ulcer, just as excessive action of the sphincter ani prevents healing of an ulcer within its grasp.

The jejunum is physiologically accustomed to alkaline contents. The acidity of the gastric juice is neutralized in the first portion of the duodenum, and when the current of food reaches the jejunum it is normally always distinctly alkaline. When the acid contents of the stomach are dumped directly into the jejunum as after a gastroenterostomy, it is natural to expect some reaction on the part of the jejunum against this change from an alkaline to an acid medium. If the urine continued alkaline for several days there would probably be a cystitis and the best method of curing the cystitis is to make the urine acid and so let the bladder contain an acid medium for which it is physiologically fitted. No matter how much of the contents of the jejunum is regurgitated into the stomach there is probably not enough to render the stomach contents constantly alkaline. In large clinics jejunal or gastrojejunal ulcers are reported as a late complication in from two to five per cent of the total number of gastroenterostomies. It seems probable that for every jejunal ulcer there must be many more instances of some reaction to the acid medium on the part of the jejunum, such as hyperemia, that will be sufficient to produce symptoms though the symptoms may not be of a very severe nature. It is likely that symptoms caused in this way account for the small percentage of complaint-free cases found in carefully traced gastroenterostomies. These complaints often do not occur until several months or years after the operation when the jejunum is no longer able to withstand the continued irritation of the acid.

The dangers of vicious circle, jejunal ulcer, volvulus, or hernia into the lesser peritoneal cavity, though not great, exist when a gastroenterostomy is done and are not present after operations on the pylorus. It must be remembered that jejunal ulcer following gastroenterostomy is caused by this operation, for I know of no reported jejunal ulcer following any form of pyloroplasty. This alone is a great burden for gastroenterostomy to carry. So great an authority on stomach surgery as W. J. Mayo[6] says he treats jejunal ulcer following gastroenterostomy by disconnecting the gastroenterostomy and doing Finney's pyloroplasty. The advantages of the prophylactic treatment for jejunal ulcer are obvious.

The pyloroplasty of Finney consists of a horseshoe-shaped incision with its center at the pylorus, one limb extending down on the mobilized duodenum and the other on the stomach near the greater curvature (Fig. 501).

[6]Mayo, W. J.: Jour. Am. Med. Assn., July 24, 1920, p. 221.

These limbs of the incision are united by suturing the posterior margin of the wound in the duodenum to the posterior margin of the wound in the stomach and the anterior margin of the wound in the duodenum to the anterior margin of the wound in the stomach (Fig. 502). Many of the objections that apply to gastroenterostomy do not obtain here as the operation is done at

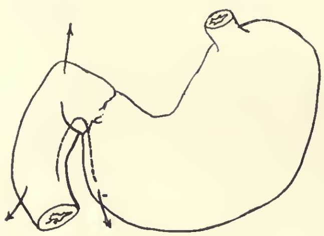

Fig. 501.—Lines of incision for pyloroplasty of Finney.

the normal physiologic outlet of food from the stomach. The results, as reported by Finney and Friedenwald, are excellent.

Finney's operation, while a distinct improvement on gastroenterostomy, is not free from objections. It seems to have been conceived partly with the idea of making it a gravity drainage operation, when, as already pointed

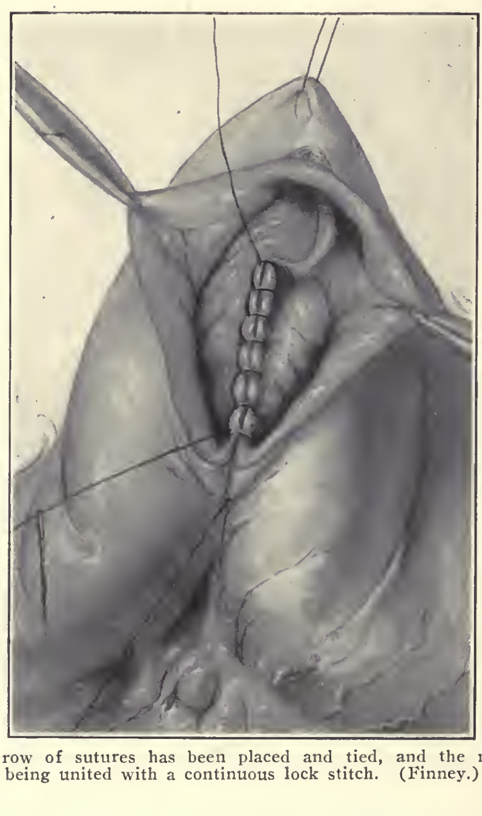

Fig. 502.—The posterior row of sutures has been placed and tied, and the margins of the wound are being united with a continuous lock stitch. (Finney.)

out, drainage of a hollow muscular organ, such as the bladder or bowel, does not have to be from the lowest point in order to be effective. Mobilization of the duodenum, which is necessary for this operation, may be quite difficult and, according to Finney, where numerous adhesions exist, his operation often cannot be done. The incision is made near the greater curvature of the stomach, where the vessels are large. The pylorus is divided in such a manner that it cannot reunite, and its sphincteric action would seem to be permanently impaired. If there is cicatricial contraction at the pylorus, scar tissue must be sutured to scar tissue, for the apex of both the posterior and the anterior margins of the sutured wound are at the pylorus.

The operation of Heineke-Mikulicz is usually supposed to be a straight incision with its center at the pylorus or at the point of constriction, the incision being sewed up transversely. Such is the description of this operation as it appears in many textbooks.[7] Binnie[8] gives a description of this operation that resembles somewhat the Finney operation.

The Heineke-Mikulicz operation in its usual conception as a straight incision with its center at the point of constriction or at the pylorus, the incision being sewed up transversely, finds but few advocates. Grey Turner[9] reports a small series of cases done by this method in which the results are quite satisfactory. As a rule, however, these objections are made to the Heineke-Mikulicz as ordinarily performed: (1) It creates a pouch with a slight constriction on the stomach side and on the duodenal side. Half of this pouch is made of the duodenum whose walls are much weaker than the walls of the stomach and it may be difficult to empty such a pouch. (2) The incision cannot be made very long because it would extend too far into the duodenum, which would have to be mobilized, and even then the tension of the sutures on the thin duodenal wall would be too great. (3) When stenosis exists, each end of the sutured wound consists of scar tissue which is sutured to scar tissue, for the center of the incision is at the point of constriction. (4) There is a tendency in healing for the pylorus to be drawn up high under the liver.

There is one part of the body in which an ulcer in the region of a sphincter has been the object of surgical observation since the earliest times of recorded surgery, and the treatment of this condition has become satisfactorily standardized. This is ulcer or fissure in ano. The analogy between an ulcer in ano and a duodenal or pyloric ulcer of the stomach which is in the region of the pyloric sphincter is striking. We know that the ulcer in ano does not heal readily because of the almost continuous action of the sphincter ani, which alternately compresses or relaxes the tissues in its neighborhood, and that in order to cure it we must employ the principle of physiologic rest and paralyze the sphincter temporarily, and at the same time excise or cauterize

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[7]Bryant: Operative Surgery, 1905, ii, 943.
Dacosta: Modern Surgery, Philadelphia, 1918, W. B. Saunders Co., ed. 7, p. 1081.
American Text-Book of Surgery, ed. 4. p. 790.
Warbasse: Surgical Treatment, Philadelphia, 1918, W. B. Saunders Co., ii, p. 738.
[8]Binnie: Operative Surgery, ed. 7, p. 385.
[9]Turner, G: Surg., Gynec. & Obst., June, 1912, xiv, 537.

the ulcer. In this manner we remove the pathologic condition and institute rest for these tissues. We would not think of treating a fissure in ano by doing a colostomy and side-switching the fecal contents, particularly if the colostomy permitted a small amount of fecal matter to continue to pass through the anus; and yet in performing a gastroenterostomy for the cure of pyloric or duodenal ulcer we are practically doing just this very thing. By using the well-known surgical principles that have been established for years for the treatment of fissure in ano, namely, temporary paralysis of the sphincter and excision or cauterization of the ulcer, we can cure practically 100 per cent of such cases. If, then, the ulcer in the duodenum or pylorus is not cancerous and is the only pathologic lesion, have we not a right to expect as good results here, so far as ultimate cure is concerned, by excision of

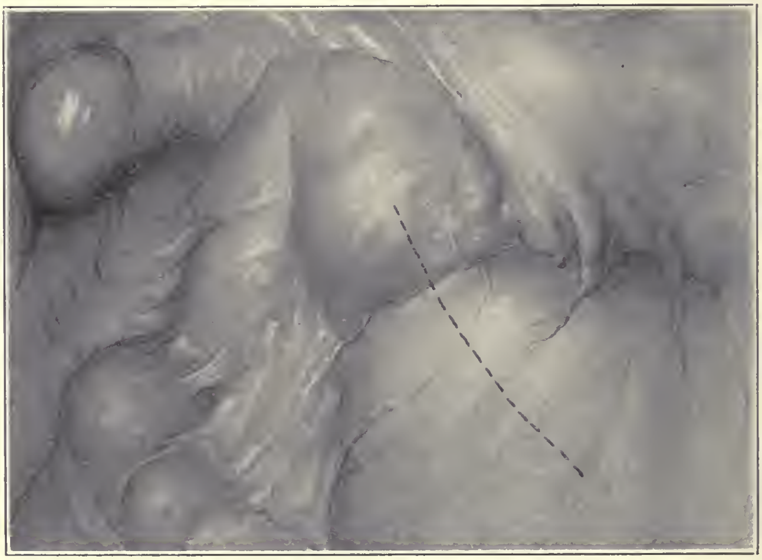

Fig. 503.—Lines of incision for the author's pyloroplasty. If the ulcer is in the midline, the incision is carried to the ulcer, which is then excised, and the excision forms the duodenal portion of the incision.

this ulcer and temporary paralysis of the sphincter muscles, as has been obtained since the early days of surgery by similar treatment of an ulcer within the region of the sphincter ani? The operation here proposed has been conceived on these principles, and an effort has been made to carry them out as far as possible, at the same time avoiding the objections that have been noted to other types of pyloroplasty. The steps of the operation are:

1. The upper portion of the duodenum and the pyloric end of the stomach are exposed through an ample abdominal incision, preferably the Bevan incision. A point is selected on the stomach not less than two inches from the pylorus and midway between the greater and lesser curvatures, and is grasped with Allis forceps or fixed with a suture. The stomach and duodenum are then surrounded with moist gauze (Fig. 503).

2. The length of the incision for the pyloroplasty depends upon the loca-

tion of the ulcer, but the stomach portion of the incision must always be at least twice as long as the duodenal portion. If the ulcer is in the duodenum and is more than three-fourths of an inch from the pylorus, pyloroplasty should not be done, but the ulcer should be excised with an elliptical incision transversely across the duodenum, according to the method of E. S. Judd of the Mayo Clinic, and the incision is closed with two rows of sutures placed transversely so that there will be no constriction of the lumen of the duodenum. When an ulcer in the duodenum is not farther from the pylorus than three-fourths of an inch, pyloroplasty gives most satisfactory results. When the ulcer is in the stomach at some distance from the pylorus, pyloroplasty should be done instead of gastroenterostomy, and here the total length of the incision need be no longer than two inches, with one-half inch of the incision in the duodenum

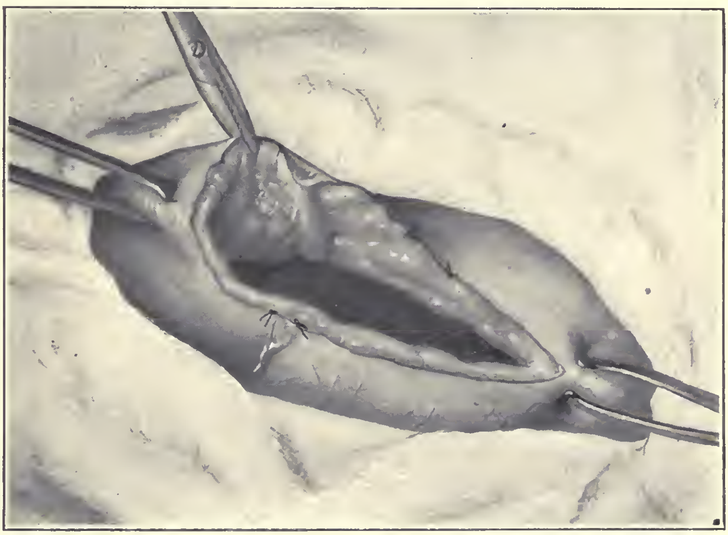

Fig. 504.—The ratio of the incision should always be at least two parts in the stomach to one in the duodenum. The incision is first carried down through the stomach and then the duodenum is opened. The vessels are tied and the ulcer is exposed.

and one and one-half inches in the stomach. For many ulcers near the pylorus a two inch incision is sufficiently long. A short incision, of course, makes the suturing easier and the operation can be completed more quickly. The incision is carried from the previously fixed point on the stomach to the pylorus, using a sharp knife and preferably cutting down to the mucosa and clamping and tying the vessels before opening the mucosa. When the mucosa is opened, the pylorus is divided and the ulcer, which is exposed, is removed. It can thus be accurately circumscribed by an incision and no more healthy mucosa is sacrificed than is necessary.

3. If there is a tendency for the gastroduodenal contents to regurgitate into the wound, a moist gauze pack is gently introduced into the stomach and a small strip of moist gauze is carefully placed in the duodenum. They should

be noted by the nurse, so there will be no possibility of overlooking the gauze when the wound is being closed.

4. If the ulcer is in the posterior wall of the duodenum or pylorus, the wound is retracted, the ulcer exposed and excised, the deeper structures are sutured with tanned or chromic catgut, and the mucosa is gently approximated

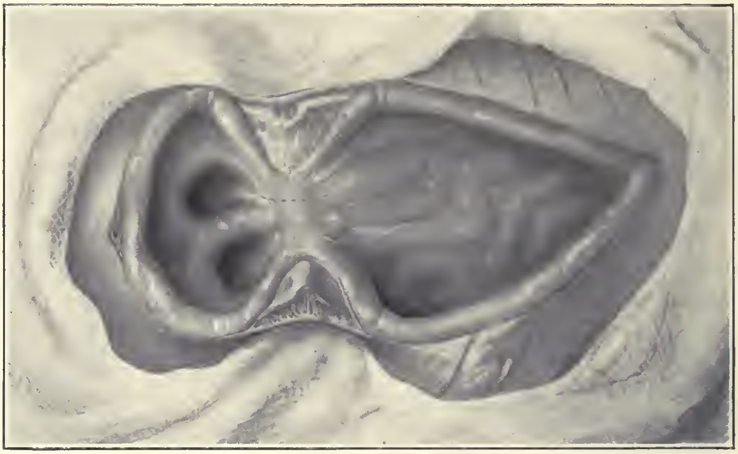

Fig. 505.—If there is marked stenosis with pocket formation on the duodenal side, the cicatricial band is divided with a superficial incision.

Fig. 506.—The posterior part of the pylorus is reconstructed with sutures as shown in the illustration, after cicatricial bands have been divided or stretched.

by a continuous suture. The suture in the mucosa must not be tight, as this might cause necrosis of the mucosa and spread the ulcer. If there is an old contraction resulting in pockets, the mucosa and the contracting band should be divided and the mucosa sutured transversely to the incision. To avoid hemorrhage, the incision that relieves the contracting band should be short and should divide only the superficial part of the band. The neglect of this precaution resulted in a fatal secondary hemorrhage (Figs. 505 and 506).

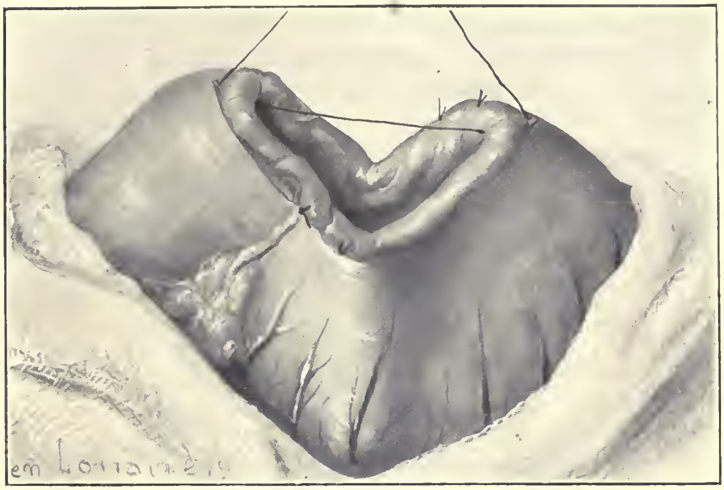

Fig. 507-*A*.—A tractor or guy suture is placed from one extremity of the suture to the other.

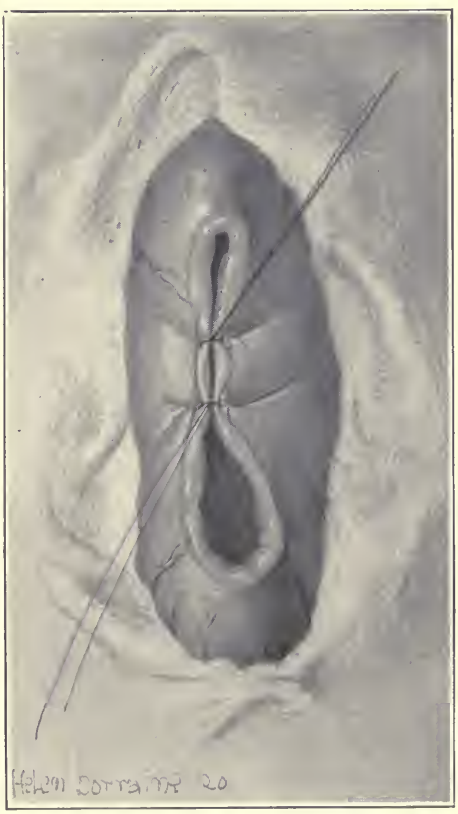

Fig. 507-*B*.—A second tractor suture is placed about one-half inch above the first. The second is tied before the first in order to relieve the strain.

5. The ulcer having been removed or pockets and contractions remedied, the ends of the incision are approximated by a tanned or chromic catgut suture (Fig. 507*A*). A second suture of similar material is placed half an inch above this middle suture and renders suturing the upper half of the incision easier. There is a tendency for a duodenal fold to form if these sutures are too far apart. Both are tied and their ends left long to facilitate suturing and to hold up the edges of the wound and so prevent injury to the posterior portion of the pylorus while suturing. (Fig. 507*B*.) A No. 1 tanned or chromic catgut

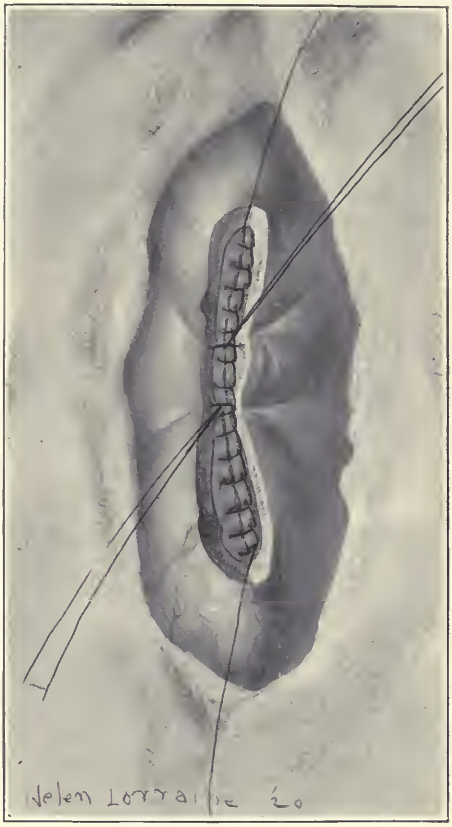

Fig. 508.—The mucosa is united with a continuous lock stitch of tanned catgut. No effort is made to secure inversion but the mucosa is merely approximated to prevent leakage.

suture is then started in the mucosa at the lowest portion of the wound, which is in the stomach wall. It is tied, the short end clamped, and the mucous membrane is united by a lock stitch which barely approximates the mucosa and ends at the upper portion of the incision, which is also in the stomach wall. Before completing this suture any gauze packing in the duodenum or stomach is removed. The suture is tied at the upper portion of the wound and the ends are left long and clamped (Fig. 508).

6. A second row of sutures, consisting of the same kind of catgut, in a curved round needle, is inserted, uniting the muscular and peritoneal coats.

This is a simple continuous stitch that approximates the edges of the peritoneal and muscular coats as a skin wound would be sutured. No attempt is made in this row to invert the edges of the wound as this would make too great a bulk of tissues along the suture line. Only enough tissue is included in the sutures to secure a firm hold. The long ends of the previous row are cut short (Fig. 509).

7. A third row of sutures of fine tanned or chromic catgut is placed, but the gauze around the stomach and duodenum should be removed before this third row is begun, as gauze packing hinders the approximation of the peritoneum.

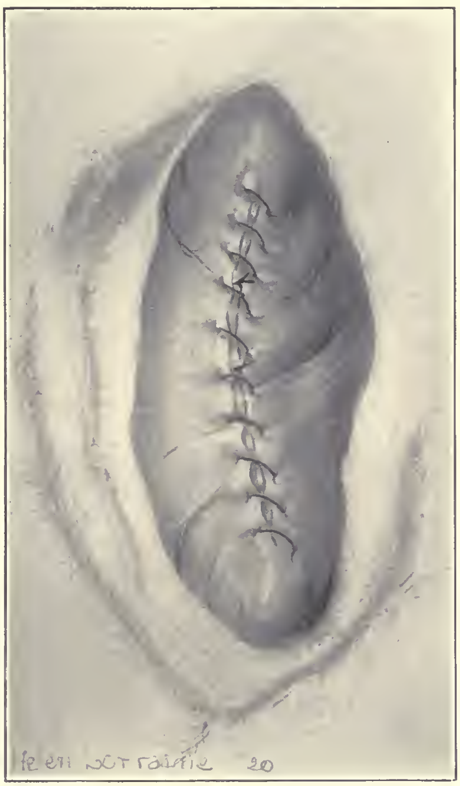

Fig. 509.—The tractor sutures have been cut. The edges of the peritoneal and muscular coats are approximated with a continuous suture without any attempt to invert the edges.

This row includes the peritoneal and muscular coats and buries the first and the second rows of sutures completely. It invests the two ends of the incision as teats. This is a continuous mattress or right-angle stitch. If the middle of the wound has not been satisfactorily approximated one or two mattress sutures of fine catgut should be placed there (Fig. 510).

8. A portion of the gastrocolic omentum, or else the right edge of the great omentum, can be brought up over the line of sutures without tension. It is fastened here with interrupted stitches of fine catgut. Care should be taken that it barely covers the upper end of the sutured wound and that it

Fig. 510.—The third row of sutures is placed as a continuous right angle suture which buries the other two rows. It is begun by surrounding the lower extremity, which forms a teat, as a pursestring suture. This is inverted as the first knot is tied. By a similar procedure the upper teat is inverted.

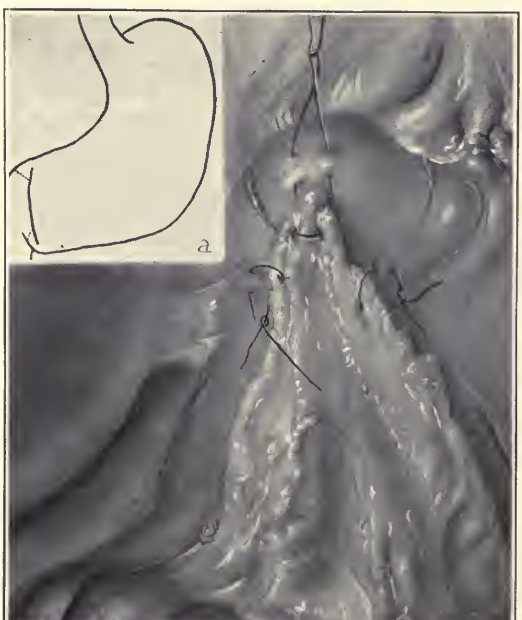

Fig. 511.—A tag of gastrocolic omentum or of the great omentum is brought up over the suture line and fastened with a few catgut sutures. This not only protects the sutures, but tends to prevent the drawing up of the pylorus under the liver as healing occurs. Insert *A* shows the contour of the stomach as it is changed by this pyloroplasty.

is not fastened to the gastrohepatic omentum, as this might result in too complete a surrounding of the pyloric end of the stomach (Fig. 511).

9. If the ulcer is not in the duodenum or the pyloric region, the operation, as just described, may be done to relieve the spasm of the pylorus and the ulcer then excised, or cauterized, as advocated by Balfour, through another gastric incision.

Where exposure is difficult or where the ulcer is in the cardiac portion of the stomach, a shorter incision in the stomach and duodenum can be effectively used. An inch and a half is often sufficient, but the ratio of one part of the incision in the duodenum to two parts in the stomach must always be observed.

The advantages of this operation are:

1. It removes the obstruction and the pathologic condition, and permits the normal resumption of the stomach function.

2. The ends of the sutured incision are within the stomach wall. The ratio of the incision should never be less than two parts in the stomach to one in the duodenum. Usually two inches in the stomach and one in the duodenum are sufficient. The anterior stomach wall in the midline can readily be pulled over to the first inch of the duodenum. In the Heineke-Mikulicz operation, and also in the upper part of the Finney operation, the ends of the sutured incision are in the scar tissue at the pylorus, while in this operation the ends of the sutured incision are within the healthy stomach wall, and the scar tissue that may remain about the pylorus is approximated, not to other scar tissue, but to healthy stomach wall. Consequently, union should be more satisfactory than where scar tissue is opposed to scar tissue, as in the other two types of pyloroplasty.

3. There is no pouch formation as in the Heineke-Mikulicz operation, in which the center of the incision is at the pylorus. The operation merely changes the shape of the pyloric end of the stomach from a funnel with gradually approaching walls to a rectangle that empties into a funnel with a more obtuse angle (Fig. 511-a).

4. The parts to be put at rest are the parts most concerned in contraction and relaxation, which are the pylorus and the adjacent portion of the stomach. By making the incision from the duodenum about 2 inches into the stomach, this is effected. A long incision into the duodenum does not help in any way.

5. The function of the pylorus and the pyloric end of the stomach is not permanently destroyed. The stomach wall that is brought over acts as a link between the ends of the pyloric sphincter and, in the course of time (usually a few weeks), the sphincter resumes its action, though, because it has been enlarged, it cannot become spastic as it was before the operation (Fig. 512).

6. The operation is simpler than the Finney operation, in which the duodenum has to be mobilized and the posterior and the anterior margins of the wound must be sutured separately.

There is a superficial resemblance between this operation and the Heineke-Mikulicz, because in both operations the pylorus is divided and in both the

incision is approximately straight. Here, however, the resemblance ceases, and the differences become marked, for, unlike the Heineke-Mikulicz, the operation described was conceived on the principle of giving temporary physiologic rest to tissues in the pylorus and the pyloric end of the stomach; the incision is longer than in the Heineke-Mikulicz operation; it is differently placed; it extends not more than one inch into the duodenum and the stomach incision is always at least double the duodenal incision; it can be considerably prolonged at the stomach end; it gives an excellent view of the pyloric end of the stomach; it requires a rather definite technic to be closed satisfactorily; it does not form a pouch with a constriction fore and aft; it does not approximate scar tissue to scar tissue; and an essential part of the operation is the removing or remedying of the pathologic condition by excising the ulcer, obliterating pockets, or incising constricting bands. In addition, the reenforcing with omentum adds security to the sutures, prevents adhesions to surrounding

Fig. 512.—A roentgenogram of a patient, Miss E. D. H., taken four and one-half months after this pyloroplasty was done. The patient had a typical duodenal ulcer with marked ptosis. There were no adhesions. The pylorus as shown is functioning normally, with a perfect duodenal cap. The pylorus is slightly larger than normal. The structure and function of the stomach have not been materially altered by this operation. The patient while using an abdominal support is complaint free.

tissues, and counteracts the tendency for the pylorus to become fixed high up under the liver, which sometimes occurs after the Heineke-Mikulicz operation.

The postoperative treatment is about the same as that employed for gastroenterostomy. If there is any vomiting or marked discomfort, the stomach should be promptly washed out under low pressure, not more than a pint of fluid being used at a time. Gastric lavage should be resorted to without hesitation and may be needed oftener than after gastroenterostomy. The head of the bed is elevated from 12 to 18 inches, and the patient is given one-half ounce of hot water every hour for the first twenty-four hours and after that 2 ounces of hot water every hour for twenty-four hours. Enemas of 6 ounces of physiologic sodium chlorid solution with one-half ounce of glucose and 1 dram of sodium bicarbonate are given every six hours for the first two days. At the end of forty-eight hours a small amount of liquid nourishment is com-

menced. About the seventh or eighth day after operation a purgative is given and soft diet is begun.

The description of this operation was reported before the section on Obstetrics, Gynecology and Abdominal Surgery, at the meeting of the American Medical Association, in June, 1919.[10] The only changes in technic since this report have been in the method of application of the second row of sutures and in placing the second stay suture closer to the first. At that time eleven cases had been operated upon by this method. There were two deaths, both of them from hemorrhage, and in both instances postmortem examinations were obtained. One death occurred on the twenty-first day after operation in a patient with an ulcer of the posterior wall of the stomach near the lesser curvature. The ulcer was removed by a transgastric incision and the resulting wound was closed with mattress sutures of stout tanned catgut. Pyloroplasty was then done. The patient made an uneventful recovery until the eighteenth day when

Fig. 513.—A drawing of the stomach removed postmortem from a patient who died twenty-one days after pyloroplasty. Death was due to hemorrhage from an ulcer involving the lesser curvature. Note the large vessel protruding in the ulcer and the healing of the pyloroplasty, which makes a wide opening.

he had a severe hemorrhage from the stomach. This appeared to be controlled by gastric lavage with hot water. Twenty-four hours later he began vomiting blood and in spite of gastric lavage and transfusion of blood he died on the twenty-first day after the operation. Necropsy was held a few

[10] Jour. Am. Med. Assn., August 23, 1919, p. 575, et seq.

hours after death and the stomach was obtained. It showed that the pylorus had healed satisfactorily, but the ulcer had extended to the lesser curvature and involved a blood vessel of considerable size that was protruding from the ulcer. From this vessel the hemorrhage undoubtedly had come (Fig. 513).

The mattress sutures in the stomach ulcer evidently were tied too tightly and caused necrosis of the mucosa and an extension of the ulcer to the lesser curvature where there were large vessels. In the light of this experience I would not close a similar ulcer with mattress sutures, but with layer sutures, uniting first the peritoneal and muscular coats. The sutures can be applied after placing a tractor suture at each end of the wound to bring it as near the abdominal wound as possible. This death could in no way be attributed to the pyloroplasty which had healed satisfactorily and left a wide open pylorus with perfect union, as shown in the illustration.

The next death occurred on the ninth day as a result of hemorrhage which began on the eighth day after the operation. This patient had a marked stenosis of the pylorus, which had existed for a number of years. This stenosis was incised posteriorly at the operation to release the constricting bands. There was moderately free hemorrhage after the incision into the bands which was readily controlled by whipping over the surface with tanned catgut. The catgut was absorbed and bleeding began on the eighth day from this incised surface. The post mortem examination showed very small vessels had been opened where the bands had been incised and the catgut was digested and absorbed. The pyloroplasty incision was in perfect condition. This error in technic could have been avoided by not cutting the bands so deeply, but merely nicking them sufficiently, so that the incision would not go through the whole thickness of the bands and reach the vessels posteriorly. Probably, too, silk sutures in this area would be preferable to catgut. Profiting by these two fatalities there has been no hemorrhage in a single pyloroplasty that I have done since this group of cases was reported. In the nine patients that recovered from operation all were complaint free in whom the ulcer was the chief or the sole pathologic lesion present.

This operation as shown by roentgenograms restores the stomach to a physiologic normal, protects the jejunum from being a dumping ground for the acid contents of the stomach, and at the same time removes the ulcer which is the cause of the patient's trouble.

After pyloroplasty it is not unusual to find pain, discomfort, and sometimes hunger pain, if there was an adherent gall bladder at the time of the pyloroplasty and the gall bladder was not removed. In order to understand this, we must remember that the ulcer of the duodenum or stomach was, in all probability, originally caused, as shown by Rosenow, by hematogenous infection with streptococci. These bacteria have to some extent a selective action, but usually there is an inflammation of the gall bladder and probably of the appendix and kidneys, from the irritation of the products of the bacteria when the ulcer is originally formed. Often the cholecystitis is rapidly overcome, but if it is severe enough to leave adhesions, that gall bladder is

permanently damaged. If, then, a pyloroplasty is done for ulcer of the duodenum or stomach when the gall bladder is adherent, it may be taken as a definite evidence of a former cholecystitis. If the adhesions are separated and the gall bladder is manipulated, a latent infection of the gall gladder is often stirred up, adhesions reform with double severity and the patient will have a recurrence of symptoms. If a gastroenterostomy is done, these symptoms will be relieved for a few months or longer, until jejunal lesions begin to give trouble.

The cause of this discomfort after pyloroplasty is due to the fact that adhesions from the gall bladder to the duodenum or pylorus, in a stomach that is otherwise normal, permit the tugging on these adhesions with each peristaltic wave and as they lead directly or indirectly to the tissues along the posterior parietal peritoneum which are supplied with spinal sensory nerves, an unusual amount of tugging will give discomfort and pain. Gastroenterostomy relieves these symptoms by permitting the stomach to empty more easily and in this way reduces the amount of peristalsis at the pyloric end of the stomach. It relieves, not by removing the pathology, but by ameliorating a symptom. This pain can be best prevented by bearing in mind the etiology of ulcer of the stomach or duodenum and removing gall bladders that are adherent. When doing a cholecystectomy under these conditions, following the technic of Murat Willis, the stump of the cystic duct should not be drained. In this manner the adhesions that might form because of the presence of the drainage tube are obviated and the stomach and duodenum are returned as nearly as possible to their physiologic normal.

There exists, however, a distinct field for gastroenterostomy. This probably does not constitute more than twenty-five per cent of the lesions of the stomach and duodenum, but there are three types of cases in which a gastroenterostomy is a better operation than pyloroplasty.

(1) In inoperable cancer of the pylorus with obstruction the necessity for gastroenterostomy is obvious.

(2) In dense and wide stenosis of the pylorus and upper duodenum when unaccompanied by hemorrhage it is difficult or impossible to mobilize the duodenum sufficiently to gain access to it and pyloroplasty is much more difficult than in simple ulcer or in a slight stenosis, that is readily accessible. Again, this type of case gives particularly good results after gastroenterostomy.

(3) In subacute perforation or in large ulcers when the pylorus and surrounding tissues are infiltrated with inflammatory products, the tissues are difficult to mobilize and do not hold sutures satisfactorily. If the infiltration is extensive it is quite probable that stenosis will result and such cases do particularly well after gastroenterostomy.

In acute perforations, however, before there is extensive infiltration of the surrounding tissues and when the duodenum and pylorus are accessible and the margins of the ulcer can be excised, the pyloroplasty described seems to be an ideal procedure, for it confines the field of operation to the region of

the perforation and avoids the possibility of spreading the infection to the lesser peritoneal cavity, which may occur if gastroenterostomy is done. If there is marked stenosis and bleeding the pyloroplasty should be done to secure the bleeding vessels or break the scar tissue band even though it is more difficult than gastroenterostomy. The pyloroplasty may be short and on account of the tendency of dense scar tissue to contract, a gastroenterostomy should also be done at the same time. These three groups will comprise a considerable minority of cases usually seen and will remove the type of cases in which pyloroplasty is quite difficult. In the average case with a single ulcer near the pylorus a pyloroplasty is easier of performance than gastroenterostomy, but with a fixed duodenum and pylorus the pyloroplasty becomes increasingly difficult. It is in this type of case, however, that gastroenterostomy gives the best results.

It has often been remarked by operators who have had much experience with pyloric stenosis that gastroenterostomy gives its best results here. Thus Balfour,[11] in speaking of the results of gastroenterostomy in obstruction at the pyloric outlet, says: "Particularly when mechanical obstruction has occurred from contraction of the ulcer or by reason of its actual size, operation is followed by eminently satisfactory results." This experience seems to be universal.

Why should gastroenterostomy give such satisfactory results in stenosis of the pylorus when the results without stenosis leave much to be desired? Stenosis of the pylorus, even when incomplete, probably becomes complete after gastroenterostomy which removes the necessity for strong peristaltic action to empty the stomach and causes a contraction of the whole stomach. It is impossible for the same intragastric pressure to be brought to bear upon the pyloric end of the stomach when a gastroenterostomy is done because the opening of the gastroenterostomy makes great intragastric pressure an impossibility. When gastroenterostomy is done for stenosis at the pylorus the gastric contents empty entirely through the gatroenterostomy. The duodenal contents with strongly alkaline reaction, which is unreduced by any gastric juice coming through the pylorus, are delivered at the site of the gastroenterostomy with maximum alkalinity. The acidity of the gastric juice is, therefore, quickly and readily neutralized, so the mucosa of the jejunum is protected from the action of a strongly acid gastric juice. When, however, the pylorus is open and gastroenterostomy is done, part of the gastric contents goes through the pylorus and part through the gastroenterostomy. That part going through the pylorus greatly reduces the alkalinity of the duodenal contents, so when the duodenal secretion reaches the gastroenterostomy opening its alkalinity is low and the acidity of the gastric contents overcomes it and acts directly upon the jejunum, which consequently registers some reaction to the presence of an acid medium.

It seems, then, that the excellent results following gastroenterostomy when there is stenosis of the pylorus occur because the high alkalinity of the duodenal contents protects the jejunum from the presence of an acid medium

[11]Collected Papers of the Mayo Clinic, 1916, viii, p. 171.

and so the jejunum has no occasion to react against an unphysiologic medium by becoming congested or by ulcer formation. Artificial closure of the pylorus has been disappointing in the attempt to simulate pyloric stenosis because practically every method of pyloric closure except excision results in the pylorus eventually opening again. While the pylorus is closed the conditions are the same as after an organic stenosis, but with the reopening of the pylorus, such as occurs after infolding or ligation, the gastric juice again escapes through the pylorus and reduces the alkalinity of the duodenal contents, with the resulting lack of protection of the jejunum. This, of course, quickly causes the same reaction on the part of the jejunum as would have occurred if the pylorus had not been closed.

Gastroenterostomy is best performed by the posterior no loop method, which has been developed by the Mayos, Moynihan and others. The operation

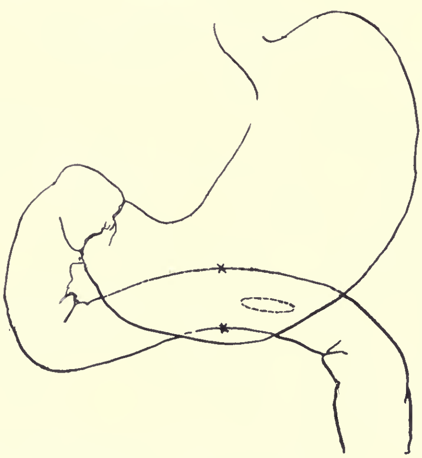

Fig. 514.—Diagram of the incisions, and direction of the opening in posterior gastroenterostomy. (W. J. Mayo).

as performed at the Mayo Clinic is a most satisfactory technic (Fig. 514). The stomach is exposed by an incision a little to the right of the midline and the stomach and duodenum are examined. The transverse colon is drawn out of the wound and pulled upward to the right to make the mesocolon taut. The jejunum is recognized as it comes out from the mesocolon and is picked up about three inches from its origin. Sometimes there is a fold of peritoneum passing from the mesocolon to the jejunum which should be divided if it extends far down on the jejunum, as this may prevent the jejunum being caught as high up as it should be. About where this fold joins the mesocolon the mesocolon is opened in a bloodless area and the posterior wall of the stomach is exposed. An opening is made sufficiently large to give exit to a considerable portion of the posterior gastric wall without constriction. Following the suggestion of McArthur, the posterior portion of the rent in the mesocolon is now sutured to the posterior part of the stomach wall by a few interrupted sutures of catgut. This procedure is best

done at this stage of the operation as the suturing can be more accurately applied than after the jejunum and stomach are united (Fig. 515).

A gastroenterostomy clamp, preferably the Roosevelt clamp, is applied to the stomach in such a way that the bite on the stomach wall will be from the right side obliquely toward the left and the tip of the forceps includes a portion of the stomach at the greater curvature. The jejunum is caught and clamped in its long axis from two to four inches from its origin, and the clamped portion is applied to the stomach so that the upper part of the jejunum is at the heel of the stomach clamp and toward the right. The surrounding tissues are protected by moist gauze and the jejunum is united to the stomach for a distance of about two and one-half inches by a row of continuous sutures, preferably of tanned or chromic catgut. The short end of the suture is clamped with

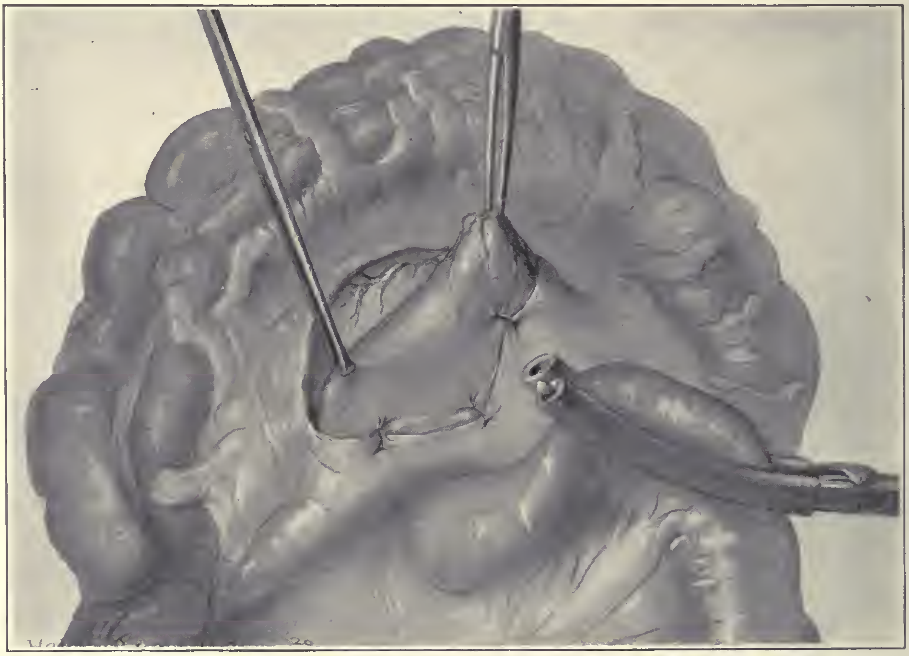

Fig. 515.—Posterior gastroenterostomy. The posterior part of the stomach is sutured to the rent in the mesocolon. The portion of jejunum to be opened is shown, but the clamp should be reversed, and its tip point to the left.

forceps. After the posterior row has been completed the needle and thread are clamped with mosquito forceps and folded in a towel. The sutures may be applied as a simple continuous stitch or as a right-angle suture, preferably the latter. The stomach and duodenum are incised about a third of an inch from this row of sutures. The incision had best be made carefully and any vessels that can be recognized should be doubly clamped and divided before opening the mucosa (Fig. 516). These vessels are then tied with catgut. This step consumes but little extra time and makes a much greater assurance that there will be no after bleeding. The mucosa of the stomach is divided throughout the length of the incision and then the mucosa of the

duodenum. The contents of the clamped stomach and duodenum are removed by sponges. A second row of sutures is begun. This is also tanned or chromic catgut but is larger than the first row, the first being 0 or 00 and the second No. 1 or No. 2. Either a curved or a straight needle may be used. This suture is begun at the end of the incision where the needle and thread of the first line of sutures has been left. The short end is clamped and the suture is continued as a buttonhole or lock stitch, each stitch being held snugly (Fig. 517). When it reaches the other end it is continued on the anterior margins of the gastric and the jejunal wound as a continuous mattress stitch penetrating all coats. A very small margin of the stomach or jejunum is caught with this suture so as not to fold in any more tissue than is necessary. If the stomach wall is quite thick this suture can often be inserted more accurately by carrying the needle from the peritoneal surface through the mucosa and then back from the mu-

Fig. 516.—The stomach and jejunum have been clamped and a posterior row of sutures is placed. The stomach and jejunum are incised down to but not through the mucosa. The next step is the clamping and tying of dilated vessels before the mucosa is opened.

cosa to the peritoneal surface. This, of course, may be accomplished by a single thrust of the needle, but in a thick stomach wall it causes a larger amount of the peritoneal and muscular coat than the mucosa to be caught in the bite of the needle, whereas if the needle is thrust in perpendicularly and returned in the same way an equal amount of all the layers of the stomach wall are grasped and there is less likelihood of bleeding points in the mucosa escaping. With a curved needle a single thrust is more likely to catch more of the mucosa than with a straight needle. Just before ending this row of sutures the clamps are relaxed to see if there is any bleeding along the posterior or the anterior margins of the wound. If there is, additional sutures

should be applied at the bleeding point. If not, this seeond row of sutures is eontinued to its point of beginning and the thread tied to the short end that was elamped.

The line of suture is earefully sponged with moist gauze and the needle and thread left after plaeing the first posterior row of sutures is taken up and the first row is eontinued, using preferably a right-angle eontinuous stiteh and going about one-fourth to one-third of an ineh from the inner row of sutures. When it reaehes its point of beginning this suture is tied to the original end that was left long. An interrupted mattress suture is taken at eaeh end of the gastroenterostomy to lessen the strain on the sutures at these points. The anterior portion of the rent in the mesoeolon is sutured

Fig. 517.—The second row of sutures has been placed in the posterior margins of the wound and is carried forward to the anterior margins.

to the stomaeh by interrupted sutures of tanned or ehromie eatgut placed about an ineh from the gastroenterostomy opening. It was formerly the eustom to suture the rent over the last row of sutures used for gastroenterostomy but W. J. Mayo found that oeeasionally this opening eontraeted and produeed eonstrietion of the gastroenterostomy stoma. By suturing the rent about an ineh higher on the stomaeh the constrietion is avoided. As one of the first steps in the operation eonsisted in suturing the posterior margin of the mesoeolon to the stomaeh the anterior or lateral aspeets are all that require suturing. This, however, is an important step in the operation. If it is not done there may be a hernia of the small intestine into the lesser peritoneal eavity.

The loeation of the gastroenterostomy opening as deseribed above is almost opposite the esophageal opening. A vieious circle whieh was formerly

common after posterior gastroenterostomy with a loop, is rarely seen when the no loop method is employed. Occasionally, however, there may be an indication for such an operation that would make a vicious circle impossible. This is done according to the method of Roux and is often called the operation "en Y." The structures are exposed as in posterior gastroenterostomy but the jejunum is caught about six inches below its origin, doubly clamped

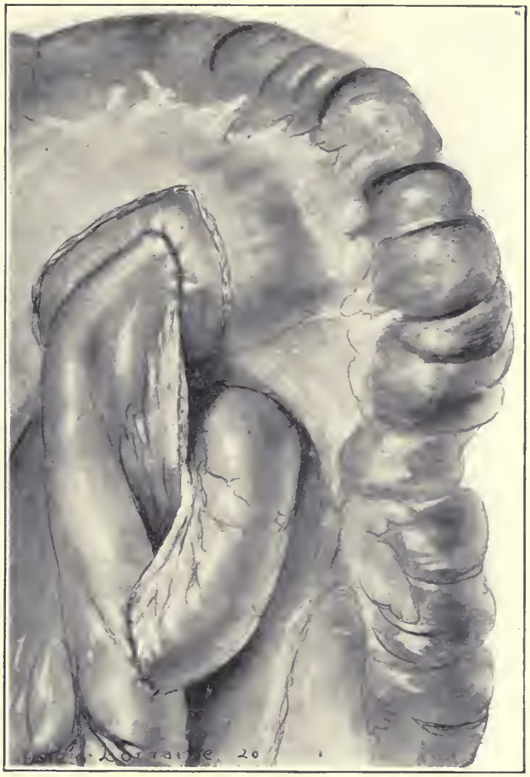

Fig. 518.—The gastroenterostomy of Roux to prevent vicious circle. This operation seems peculiarly liable to be followed by jejunal ulcer.

and divided. The lower end is sutured to the posterior wall of the stomach which is exposed as in the operation of gastroenterostomy just described. The upper end is sutured by the end-to-side method to the jejunum about five inches below the gastroenterostomy opening (Fig. 518).

Excision of an ulcer should be done wherever possible. This procedure not only removes a septic focus, but when the ulcer is in the stomach it lessens the possibility of cancer which occurs in a certain percentage of ulcers of the stomach. When the ulcer is on the anterior surface of the stomach and near the pylorus, excision is readily done. This may be accomplished through the pyloroplasty incision made in such a way that it will be near the edge of the ulcer, which is excised from the mucous surface. It is best to cauterize the ulcer with the cautery to sterilize its surface before removing it.

When the ulcer is so located that it cannot be readily brought into the region of the pyloroplasty incision, it is removed through a separate incision. A frequent site of gastric ulcer is along the lesser curvature. The blood vessels in the mesentery are ligated along the edge of the ulcer and the gastrohepatic omentum is divided. The portion of the stomach containing the ulcer is mobilized as much as possible and surrounded by moist gauze. With a sharp knife an incision is made along the margin of the ulcer cutting down to, but not through, the mucosa. Bleeding points are clamped and tied by transfixing them with catgut in a needle. It will be found that the mucosa is more easily mobilized than the other layers of the stomach wall. After circumscribing the ulcer in this manner the mucosa is opened with the electric cautery at its anterior portion and the ulcer is inspected. The rest of the mucosa is then divided with the cautery in such a way that there is a small margin of healthy mucosa excised with the ulcer. The mucosa is sutured as a separate layer with tanned catgut, using a continuous lock stitch. If the sutures can be placed in a straight line, without too much tension, it should be done. The incision in the stomach may often be made in an oblique- or diamond-shaped manner which will render such a closure not difficult. The important point is to unite the edges of the mucosa without tension. A second row of sutures of No. 1 tanned or chromic catgut in a curved round needle is placed taking the muscular coat and edges of the peritoneum. This may be placed as a right-angle stitch, taking an occasional back stitch in order to anchor the line of sutures at about every fourth insertion of the needle, or if there is tension the second row is inserted, as the second row in pyloroplasty. A third row of finer tanned or chromic catgut is inserted as a right-angle stitch. The stumps of the ligated gastrohepatic omentum are brought together over the wound and fastened with interrupted catgut sutures. Suturing the ulcer in this manner will take up a minimum amount of the wall of the stomach and will produce but little tension. If through-and-through sutures are taken as the first layer a large mass of inverted tissue is turned in which not only encroaches greatly on the wall of the stomach, but is likely to cause tension on the sutures and make an unnecessary lump of tissue.

Ulcers on the posterior gastric wall are often difficult to approach. If adherent to the pancreas their excision may be complicated. If the ulcer is near the lesser curvature it can be reached by ligating and dividing the gastrohepatic omentum immediately above it and making a vertical incision over the upper portion of the anterior stomach wall, which will expose the ulcer, and then continuing the incision posteriorly as an elliptical or diamond-shaped incision that will include the ulcer. The wound is then sutured by placing tractor sutures in the posterior angle and drawing the wound forward. Suturing is begun in the mucosa at the posterior angle and carried forward to the anterior end of the incision as a continuous lock stitch of tanned or chromic catgut. The second row is of tanned or chromic catgut to approximate the margins of the wound, and the third is of finer tanned or chromic catgut placed

as a right-angle stitch. The gastrohepatic omentum is brought together as in excision of an ulcer on the lesser curvature.

When the ulcer is near the middle of the posterior wall it can be reached by a transgastric incision. This may be vertical or longitudinal in the anterior wall of the stomach. If a longitudinal incision is made it should be about midway between the lesser and greater curvatures so as to avoid the larger blood vessels and to injure as little as possible the nerve supply. If the ulcer is nonadherent it may be pushed into the wound by the hand, which invaginates the transverse mesocolon into the lesser peritoneal cavity and

Fig. 519.—Incision through the gastrohepatic and gastrocolic omentum to expose ulcer in posterior wall of the stomach.

shoves the posterior wall of the stomach into the wound. If the ulcer is adherent, the lesser peritoneal cavity is opened either through the gastrohepatic omentum or the gastrocolic omentum and the region of the ulcer is carefully packed around with moist gauze to prevent soiling of the surrounding tissue (Fig. 519). The adhesions may then be carefully separated with the finger in the lesser peritoneal cavity or if they are dense they may be separated after incising the margin of the ulcer from within the stomach through an incision in the anterior gastric wall. Such an incision should be carried along a margin of the ulcer for a short distance and carefully enlarged and deepened until the stomach has been penetrated. Then with the fin-

ger the margins of the ulcer may be separated. If the pancreas is involved a small portion of the pancreas may be cut away and the bleeding surface whipped over with tanned or chromic catgut which is tied just tightly enough to control the bleeding. Here it would be wise to carry a cigarette drain down to the injured pancreas and bring the drain out through the rent in the gastrocolic omentum. After mobilizing the ulcer it is brought up into the wound, its surface is cauterized with an electric cautery, and the ulcer is excised. Bleeding points are secured by transfixing them with catgut in a needle. The peritoneal and muscular coats are sewed with interrupted mattress sutures of tanned or chromic catgut. The ends are securely tied and cut short and a second layer of tanned or chromic catgut right-angle suture is applied to include the muscular wall of the stomach and some of the submucosa. The third row is a continuous lock stitch of fine tanned or chromic catgut in the mucosa. This method is much safer than endeavoring to place interrupted mattress sutures of stout catgut or silk through the whole gastric wall for these sutures must be tied tightly to secure approximation and the blood supply to the tissues within their grasp is either diminished or cut off entirely. There will, consequently, be necrosis, and though the peritoneal surfaces of the stomach may unite, the mass of tissue within the grasp of the sutures in the interior of the stomach, including a considerable amount of mucosa, will probably die. This gives rise to a new ulcer that may be more extensive than the original one.

Not infrequently on account of adhesions, the extent of the ulcer, or its inaccessible location it is impossible or exceedingly difficult to excise the ulcer. Here the method of cauterizing the ulcer as devised by D. C. Balfour, should be employed. According to the technic of Balfour, the gastrohepatic omentum in the region of the ulcer is dissected free from the lesser curvature. An ulcer that requires cauterization and cannot be safely excised is always along the lesser curvature. After exposing the region of the ulcer a flap of tissue over it, including the peritoneum and muscular coat, is raised, the crater of the ulcer is demonstrated and is perforated by a Paquelin or an electric cautery at a dull red heat. The cauterization is continued until the whole of the surface of the ulcer has been destroyed. The margins of the cauterized area are then brought together by interrupted sutures of chromic catgut and over this are placed mattress sutures of silk. Lastly a flap of gastrohepatic omentum, which was originally loosened and preserved, is sutured over the wound.

After excision of any ulcer a pyloroplasty should be done to overcome the spasm at the pylorus. The pyloroplasty which has been described will suit admirably and when done to relieve the spasm at the pylorus that follows the excision of an ulcer in the body or cardiac portion of the stomach, the total length of the incision need be only about two or two and one-half inches, taking care, however, that no more than one-third of the total length is in the duodenum and the rest of the incision is in the stomach. Any operation upon the stomach interferes with its peristalsis and emptying power. Just as an

operation upon the urinary bladder interferes with its power to empty and should be followed by the introduction of an indwelling catheter, so an operation upon the stomach must provide easy exit for its contents by overcoming the resistance at the pylorus. The pyloroplasty does this without instituting the unphysiologic conditions already described which necessarily follow a gastroenterostomy, and by the time the wound in the stomach has thoroughly healed the pyloric end of the stomach functions in a practically normal manner. There should be no hesitation about the use of a stomach tube after such operations upon the stomach. If the stomach tube is used with reasonable care and if the stomach is washed out with a small amount of soda solution under low pressure, this will be much less trying upon the healing of the wound than the retention of gastric contents or the tension upon the suture line from a stomach dilated with liquid or gas.

In old ulcers with pronounced hourglass constriction or where a considerable portion of the gastric wall is involved a transverse or sleeve resection of the stomach often produces better results than an extended V-shaped resection. The sleeve or transverse resection is performed after ligating the vessels in the gastrohepatic omentum along the margins of the proposed incisions for resection. The gastrohepatic omentum is divided and the lesser peritoneal cavity is packed with moist gauze. With the hand in the lesser peritoneal cavity the gastrocolic omentum is raised in such a manner as to avoid injury to the transverse mesocolon. The gastroepiploic arteries are clamped, divided and tied at about the proposed lines for the excision, just as the gastric and pyloric have been tied in the gastrohepatic omentum. This section of the stomach is thus mobilized and packed off from the surrounding tissues with moist gauze. A long rubber-covered stomach clamp is placed as far to the cardiac side as possible in order to occlude the stomach and to leave a margin of about one and one-half inches of stomach after the excision has been done. A similar clamp is placed on the pyloric portion of the stomach. If there is no reasonable suspicion of malignancy the diseased segment of the stomach is now cut away with knife or scissors. If, however, malignancy is suspected the incision in the stomach had best be made with an electric cautery. The posterior peritoneal surfaces of the stomach wall are united by a series of interrupted mattress sutures of silk or linen, which include the peritoneal and muscular coats. It is best to insert all of these sutures before tying any. After tying them the ends of the sutures are cut short except the ends at the greater curvature and at the lesser curvature. These are left long and act as tractor sutures.

The pressure on the stomach clamps should be slightly relaxed to demonstrate bleeding points. If there is spurting at any point the vessels are controlled by transfixing the tissues around them with catgut in a needle. The clamps are then tightened and a continuous suture of No. 1 or No. 2 tanned or chromic catgut is begun at the upper margin of the wound and penetrates all coats of the stomach, being inserted from the surface of the mucosa. Care is taken to begin the sutures a little ante-

riorly to the upper extremity of the incision. After tying the knot three times the short end is clamped with forceps. The suturing is continued as a lock stitch snugly applied over the posterior margin of the wound. When it reaches the greater curvature it is converted into a right-angle continuous suture penetrating all coats, but taking a bite of peritoneum close to the wound and locking every fourth insertion of the needle by a back stitch, by taking a bite in the tissue a little behind the stitch that has just been inserted. Just before reaching the point of beginning of the suture, the clamps are relaxed and bleeding points are again looked for and controlled by interrupted sutures of catgut. The suture is continued and tied to the original end which was clamped with forceps when the first knot was tied. A second layer of either continuous right-angle sutures of fine tanned or chromic catgut or interrupted mattress sutures of silk or linen is applied. At the upper angle an extra suture is placed to relieve tension at this point. The stumps of the gastrohepatic omentum, where the blood vessels have been tied, are brought over the wound and fastened with interrupted sutures. A similar procedure is done at the lower angle of the wound, fastening the gastrocolic omentum over the wound in this region. A pyloroplasty should be done in order to relieve the spasm at the pylorus. This requires only a short incision in the stomach and duodenum.

The technic of excision of the stomach for cancer has been greatly improved by the method of Polya which is now quite generally adopted. Formerly gastrectomy for cancer, which usually involves the pyloric end of the stomach, was done according to the second method of Billroth. This consists in excising the pyloric end, closing the duodenum and the stomach and doing a gastroenterostomy. It was not only a tedious operation, but the technic of gastroenterostomy performed on the small stump of the cardiac end of the stomach is quite difficult and involves tissue whose nutrition is impaired by the ligation of some of the vessels that supply the stomach, which, of course, is necessary in the performance of the excision.

The principle of the Polya operation consists in applying the jejunum directly to the wound in the stomach. The advantages of this procedure are obvious. It enables more of the stomach to be removed because the wound by the old technic was infolded and carefully sutured, which takes at least an inch more of the stomach than when it is sutured directly to the jejunum. Then, too, the nutrition of the stump of the stomach is augmented by applying to it a loop of jejunum whose blood supply has been unimpaired. The time of the operation is shortened by removing the necessity of a gastroenterostomy.

According to the original Polya method the jejunum was brought up through a rent in the mesocolon as in gastroenterostomy. D. C. Balfour has added a great improvement in this technic by bringing the loop of jejunum over the transverse colon as when an anterior gastroenterostomy is performed. The technic of Balfour's modification of the Polya operation is as follows: The vessels that supply the pyloric portion of the stomach are ligated at a short distance from the proposed line of excision, the gastric artery being first

doubly clamped, divided and tied in the gastrohepatic omentum and then the pyloric artery is similarly treated. As much of the gastrohepatic omentum as possible is removed, including all enlarged glands and going as high up on the lesser curvature as is practicable. Lymphatic metastases extend along the lesser curvature more rapidly than at other points. After the vessels at the lesser curvature have been secured and the gastrohepatic omentum has been divided, the lesser peritoneal cavity is entered from above by inserting the hand and lifting the stomach forward. The gastroepiploic artery along the greater curvature of the stomach is doubly clamped, divided, and tied. The

Fig. 520.—Gastrectomy. The stomach has been mobilized and isolated except at its pyloric and cardiac ends. The crushing clamps have been placed and the lines of incision are indicated. The pylorus is first divided.

gastrocolic omentum is divided near the colon, the vessels being doubly clamped before they are divided. Care is taken in this region to avoid injury to the blood vessels of the transverse mesocolon. If the colic artery is injured it may be necessary to resect the transverse colon, which would be a grave complication in these cases. By working from the cardiac end toward the pylorus and pushing the transverse colon out of the way such an accident should be avoided. The right gastroepiploic artery is doubly clamped and divided near the beginning of the duodenum. Here the mesocolic vessels are very near. All vessels that have been clamped are now tied so as to have as few forceps in the field as possible.

The large Payr crushing clamp is applied to the body of the stomach at the line of the proposed resection. Two smaller Payr clamps are placed on the duodenum near the pylorus. The segment to be removed may be clamped with ordinary pedicle or stomach forceps instead of the Payr instrument which should always be used on the remaining stumps. (Fig.

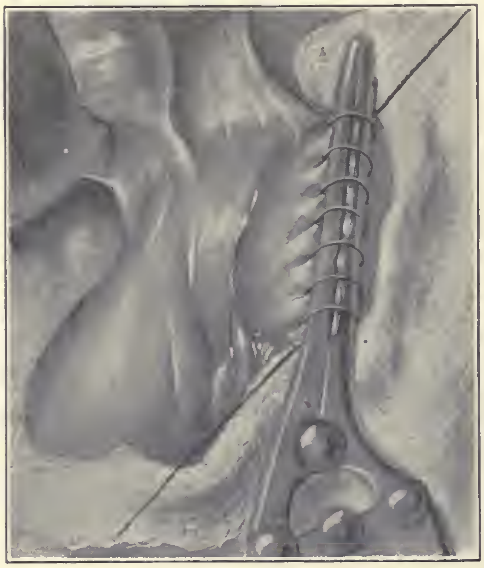

Fig. 521.—The duodenal stump is sutured over with a right-angle continuous suture which is drawn tight after the clamp is removed.

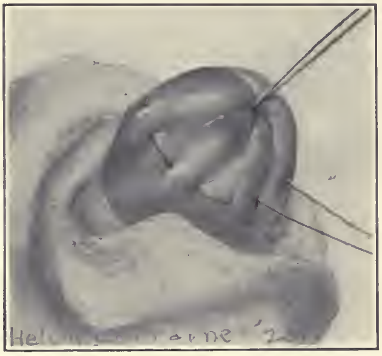

Fig. 522.—Pursestring sutures are added still further to invaginate the duodenal stump.

520). The stomach is divided with the electric cautery at the pyloric end. The duodenum is closed by a pursestring suture of tanned or chromic catgut. This end is further inverted by a pursestring suture of silk or linen applied about half an inch from the original suture and still another pursestring suture is placed to bury this second suture (Figs. 521 and 522). A few interrupted sutures of silk or linen are placed to draw the capsule of the pancreas

and the omentum in the neighborhood over the end of the duodenum and bury it. The diseased segment of stomach is completely severed by dividing the stomach with an electric cautery between the two large clamps. A loop of jejunum is picked up about eighteen inches from the beginning of the jejunum and is carried in front of the transverse colon and omentum. It is longitudinally clamped with a long rubber covered stomach clamp and so applied to the stump of the stomach as to make the distal end of the loop approximate the greater curvature of the stomach. In this way the normal peristalsis of the jejunum would go from the upper border of the stomach downward to the greater

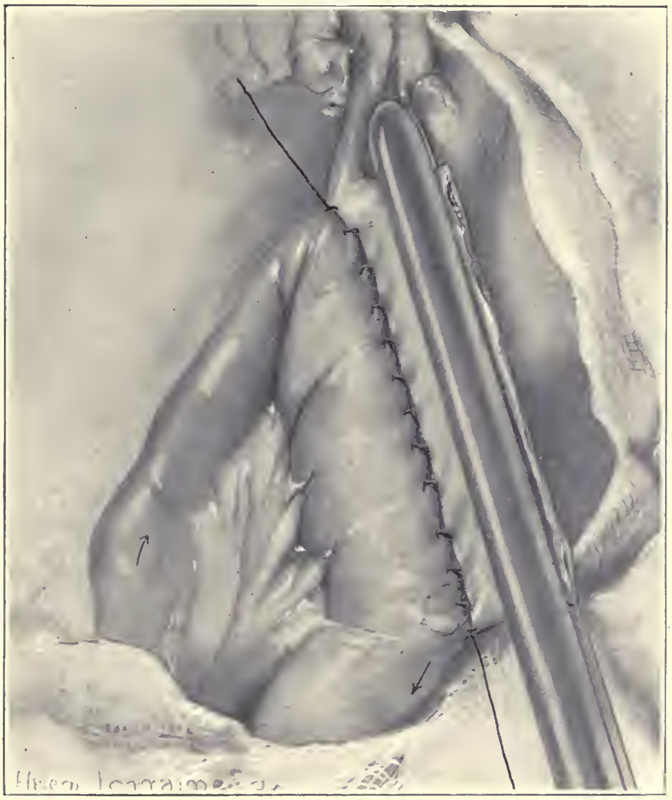

Fig. 523.—The stomach is severed at its cardiac portion and a loop of jejunum is brought up and sutured to the stomach. The peristaltic current in the jejunum should run from the upper border of the stomach to the lower border as indicated by the arrows (Polya-Balfour).

curvature. Two interrupted mattress sutures are placed, one at the upper and one at the lower border of the stomach. The ends are left long so they may be used as tractor sutures. The loop of jejunum is united to the posterior wall of the stomach by a continuous right-angle suture of silk or linen. This row is applied about half an inch behind the Payr clamp by turning the clamp to bring this part of the posterior stomach wall prominently forward (Fig. 523). After these sutures are inserted a long, straight, rubber covered clamp is placed on the stomach about two inches, if possible, from the Payr crush-

ing forceps. The Payr clamp is removed and the margin of the stomach wall which was crushed with the Payr clamp is trimmed away with scissors, as this crushed portion will not make a satisfactory union and may cause cicatricial contraction. A slight relaxation of the pressure of the stomach clamp will indicate where the bleeding points are to be controlled with interrupted catgut sutures. The loop of jejunum is incised along its convexed border in a similar manner as in gastroenterostomy. The incision should not be quite as long as the wound in the stomach. The jejunum is united to the stomach in the same manner as described in the sleeve resection; that is by begin-

Fig. 524.—The second row of sutures is placed as the second row in gastroenterostomy. The original first row is then continued anteriorly.

ning a tanned or chromic catgut suture at the upper margin of the wound, clamping the short end of the suture, and uniting the posterior margin of the gastric wound to the posterior margin of the wound in the jejunum with a continuous lock suture snugly applied (Fig. 524). At the lower angle of the wound the suture is continued forward as a right-angle continuous stitch penetrating all coats and taking a small margin of peritoneum. This suture may be locked by a back stitch about every fourth insertion of the needle. Just before completing the suture the clamps on the stomach and jejunum are slightly relaxed to demonstrate if there is any

marked bleeding point. If so, it is controlled by interrupted sutures of catgut. The suture is then completed and tied to the original end. Another row of right angle sutures of silk or linen is placed and at the upper end of the wound an extra suture is applied. The stump of the gastrohepatic omentum is drawn over the wound at this point and fixed with interrupted sutures. The lower end of the wound is similarly protected.

There is no occasion for anastomosis between the limbs of the loop of jejunum. The loop, of course, should be so selected as to put no tension on the bowel at any point, but at the same time to leave no marked redundancy. Sometimes the wound in the stomach seems abnormally large, and this may be treated in one of several ways. The opening in the jejunum may be made not so large as the opening in the stomach and the excessive amount of the wound of the stomach may be closed or sutured to the unopened part of the jejunum. Recently C. H. Mayo has practiced closing the lower part of the gastric wound and uniting the jejunum to the upper portion, as the propulsive waves of peristalsis force the food current to the pylorus along the lesser curvature. There seems to be no real objection to a large opening, however, unless there is marked dilatation of the stomach when partial closure of the wound before uniting the jejunum to it can be made according to the method of C. H. Mayo.

The removal of foreign bodies may demand an incision into the stomach. This is usually easily accomplished. The stomach is incised either longitudinally, about midway between the greater and lesser curvatures, or transversely. The surrounding tissues are protected with moist gauze and the wound is closed, preferably by the method described after excision of ulcers or pyloroplasty; that is with three rows of sutures, the inner row being a continuous lock stitch of fine tanned or chromic catgut in the mucosa, the next a simple continuous stitch of coarser tanned or chromic catgut, and the last a continuous right-angle suture of fine catgut including the peritoneum and muscle.

In cancer or stricture of the esophagus it may be necessary to do a gastrostomy to keep the patient from starving to death. This may be done by one of several methods. The choice of operations depends to some extent upon the local conditions. If the stomach is large, Frank's operation is often used. An incision is made through the upper part of the left rectus muscle, the fibers of the muscle being split, and after the peritoneal cavity has been opened a cone-shaped piece of the anterior wall of the stomach is brought well into the wound. The base of the cone is fixed to the margins of the parietal peritoneum by a continuous suture of silk. A second incision is made about parallel to the costal margin and an inch above its free edge. The subcutaneous tissue is undermined between the two incisions so as to raise a bridge of skin, and through this undermined portion the tip of the cone of the stomach is carried until it reaches the second incision. It is here fixed by a few sutures and the skin of the original abdominal wound is

completely closed. The apex of the cone is opened and a tube is inserted. This method can only be used when the stomach is greatly enlarged and even then it is probably inferior to the other tube methods, as the stomach is too greatly fixed and its motion is too much interfered with by this operation.

In the Senn method, after exposing the stomach through an incision about three inches long through the outer portion of the left rectus, it is pulled into the wound. Usually the stomach is small and retracts under the margins of the ribs. A point on its anterior border is selected for the insertion of a tube. This should be about midway between the lesser and greater curvatures and as near the cardiac end as possible. This point is pulled well into the wound and, after protecting the surrounding tissues with moist gauze to prevent soiling, a small incision is made into the stomach. Through this

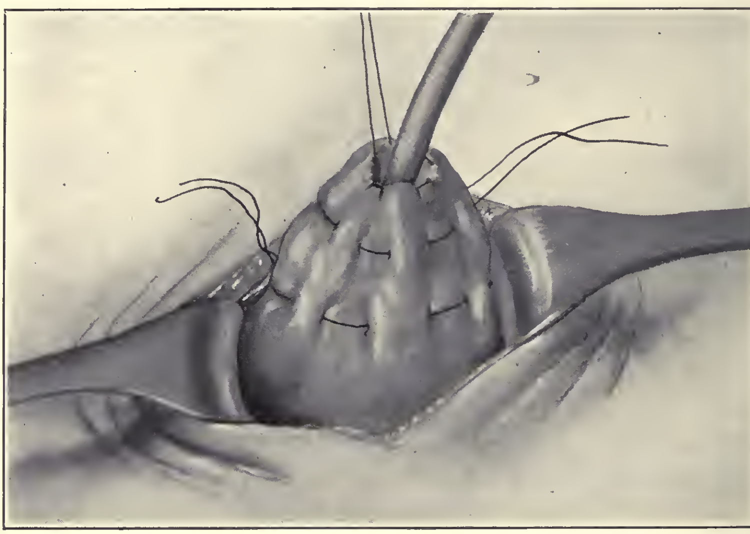

Fig. 525.—Gastrostomy, according to the Senn method.

opening a large-sized soft rubber catheter with an extra perforation near its eye is inserted and passed toward the pylorus for two or three inches. The tube is fixed in position by a tanned or chromic catgut suture which surrounds the margin of the opening and also takes a bite in the tube. This suture is tied and a series of pursestring sutures of linen or silk is passed in concentric circles in the stomach wall around the tube (Fig. 525). The first of these is half an inch from the tube and as the suture is being tied the tube is shoved in, so making an inverted cone. The second pursestring suture is about a quarter of an inch from the preceding suture and is passed and tied in the same manner. Three or four such sutures are applied. The stomach is anchored to the parietal peritoneum by sutures above and below the tube and the abdominal incision is closed in layers, allowing the tube an exit. Six or seven ounces of peptonized milk may be given on the operating table. The tube is clamped after the feeding. The

junction of a tube inserted in this way is water tight and the clamp is only removed when a feeding is given.

In the Witzel operation a tube is introduced in much the same manner as in the Senn method and fixed by sutures, but the tube is buried by suturing the wall of the stomach over the tube so that the tube lies in a groove or furrow instead of in the middle of a cone. These sutures are interrupted and of silk or linen (Fig. 526). The stomach is fixed to the abdominal wall in a similar manner to that described after the Senn gastrostomy.

Resection of the whole stomach for cancer and anastomosis of the jejunum to the esophagus either according to the "Y" technic of Roux or bringing up a jejunal loop is possible. Excision of the whole stomach has been done but indications for such an operation are exceedingly rare. If it is necessary to remove all of the stomach to eradicate malignant disease, it is highly prob-

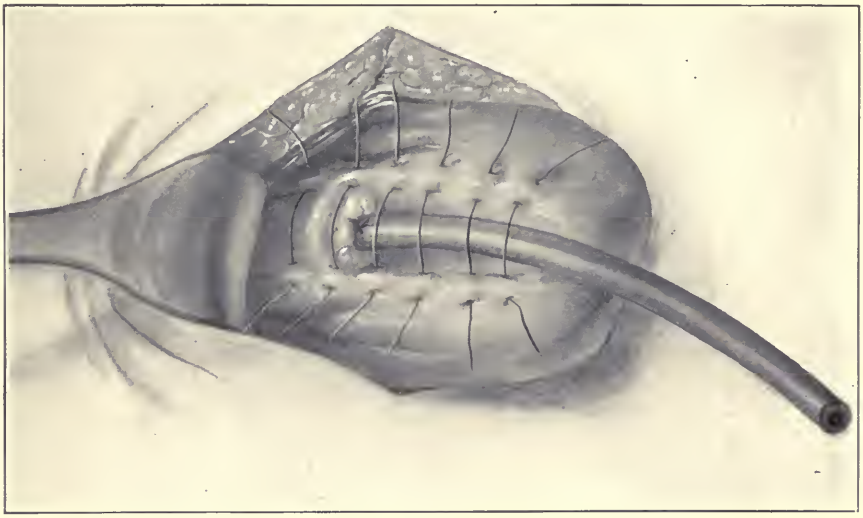

Fig. 526.—Gastrostomy according to the method of Witzel.

able that metastases elsewhere have occurred to such an extent as to make the radical operation of complete gastrectomy exceedingly unlikely to cure.

In complete occlusion of the lower end of the esophagus, operations have been devised by which a tube is made from a flap of the stomach taken from the greater curvature and so shaped that it has an abundance of nourishment. This flap is fashioned by sutures into a tube and is brought up beneath the skin and connected by a rubber tube with the esophagus in the neck. The operation has not been tried out sufficiently to have a good standing in surgical operations, but in certain rare instances it might be considered.

A peculiar condition of the pyloric end of the stomach, known as congenital pyloric stenosis, occasionally occurs. This is usually observed in infants from one to four weeks after birth. It consists of a great hypertrophy of the muscular coats of the pylorus and the adjacent portion of the stomach.

The hypertrophy is so great as to form a tumor which sometimes can be palpated externally. The marked projectile vomiting and the characteristic visible peristaltic waves of the stomach, together with the peculiar worm-like peristalsis of the pyloric end which has been noted by A. A. Strauss under fluoroscopic examination, make the diagnosis reasonably certain. The necessity of an operation depends upon the degree of the stenosis. Formerly these cases were operated upon by a posterior gastroenterostomy which carried a rather high mortality, but the operation of Rammstedt is better. This consists in incising the hypertrophied pyloric fibers down to the mucosa, but the mucosa itself is not incised. The margins of the severed hypertrophied mus-

Fig. 527.—The operation of Rammstedt for congenital pyloric stenosis. The hypertrophy is carefully incised almost to the mucosa and the margins of the wound are pushed apart as shown in the illustration.

cle fibers are pushed apart by spreading the blades of a forceps (Fig. 527). This operation, which is done through a short right rectus incision, can be quickly performed and the results are a distinct improvement over the results obtained by gastroenterostomy.

A. A. Strauss[12] has devised an operation, which, in his hands, has given excellent results with a mortality of only three deaths in one hundred and three consecutive cases. This operation is based on experimental work done by Strauss in 1912 and 1913. According to his technic an incision about one inch long is made through the fibers of the rectus muscle in the right hypo-

[12]Surgical Clinics of Chicago, Feb., 1920, Philadelphia, W. B. Saunders Co., 93, et seq.

chondriac region over the pylorus. Often a tumor can be felt which renders the location of the incision more accurate. The index finger is inserted through the incision and a ribbon-shaped hook is introduced into the wound along the index finger to the hypertrophied pylorus which is brought up into the wound by this hook. If this cannot be readily done or a hook of this type is not available, the incision may be enlarged until the pylorus can be delivered into the wound without difficulty. The practice of Strauss, however, is to deliver the pylorus by this hook, working through a small incision in order to avoid unduly exposing the other portions of the stomach or the intestines. After delivering the tumor, which consists of the hypertrophied pylorus, an incision is made in the more bloodless region of the pylorus. This incision is longitudinal and is made with a sharp knife, going through only the superficial layers of the hypertrophied muscle. The rest of the fibers are separated with the handle of a scalpel to the

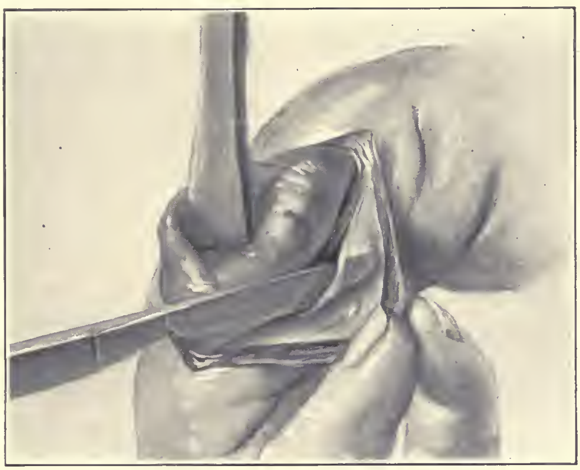

Fig. 528.—Operation for congenital pyloric stenosis according to Strauss. The mucosa is mobilized around its entire circumference.

stomach side of the growth where it merges into the normal musculature of the stomach. Working to the mucosa of the stomach in this manner and in this region gives a line of cleavage between the mucosa and the muscular coat that is easily obtained and makes it possible to split down the hypertrophied muscle to the duodenum without the accident of puncturing the mucosa of the duodenum, which is a very grave danger in the usual method of performing the Rammstedt operation (Fig. 528). The edges of the divided hypertrophied muscle fibers are caught and pulled apart with the fingers and thumb, using a piece of gauze to secure a firm hold. This causes the mucosa to separate from the muscular coats in the stomach and also breaks the few remaining muscle fibers toward the duodenal end. These fibers are often responsible for constriction and when divided with a knife injury to the mucosa of the duodenum is likely to occur. By this method they are torn apart instead of being cut. The mucosa is completely shelled

out by blunt dissection from the muscular layers of the hypertrophied pylorus. This causes the mucosa to unfold. Strauss completes the operation by splitting a flap from the inner portion of the hypertrophied muscle fibers as shown in the illustration. This flap hinges along one edge of the incision and is turned over the exposed mucosa and fastened with a few interrupted sutures of fine silk to the other edge of the incision (Fig. 529). This covers the mucosa completely. The free end of the omentum is brought over the flap and sutured in position. A cross section of the completed operation shows a lumen well established with the mucosa distended and at the same time protected in its anterior portion by the flap which has been cut from the hypertrophied muscle (Fig. 529-A). The method of completely mobilizing the mucosa without the danger either of perforation of the duodenal mucosa or of leaving a few obstructing fibers, presents two great advantages, the lack of which has been responsible for most of the deaths after the Rammstedt operation.

Fig. 529.—Operation for congenital pyloric stenosis. A flap from the hypertrophied tissue is made and is sutured in position. Insert *A* shows a cross section of the completed operation (Strauss).

Occasionally for a local lesion a resection of the pylorus is indicated which may be so limited in character as to permit the union of the duodenum to the stomach. If this can be accomplished the union may be done according to the original method of Billroth in which the duodenum is sutured to the wound at the lower border of the stomach and the upper portion of the stomach wound is closed. Or the duodenum may be inserted into the posterior wall of the stomach a short distance behind the line of incision in the stomach. This latter method of Kocher is probably less likely to be followed by leakage at the line of union of the duodenum and stomach than is the method of Billroth, though the danger of leakage in Billroth's original operation can be greatly lessened by reinforcing the line of union with a transplanted flap of omentum.

CHAPTER XXVI

OPERATION ON THE INTESTINES

THE TECHNIC OF SUTURING WOUNDS OF THE STOMACH AND INTESTINES

The technic of suturing the stomach and intestines varies considerably because of the difference in the anatomical structures of these organs, as well as in the nature of their physiologic action. The stomach is a large organ with a very thick muscular wall that consists of several layers of muscular fibers running in different directions. The intestinal wall is much thinner and has only two layers of muscle, the external being longitudinal and the internal circular. The great thickness of the gastric wall together with its peculiar churning and propulsive motions produces considerable strain upon a sutured incision in the stomach. The much greater tendency to ulceration in the stomach than in the intestines, particularly in the small intestine, must also be taken into consideration. Suture material should be provided for the stomach that will not remain as a permanent foreign body to become a focus of infection or the site of an ulcer. In the intestine sutures appear to work into the lumen more readily than in the stomach, possibly because the walls are thinner and the peristalsis is usually in a direction that tends to drag any projecting portion of the sutures along with the fecal current. Sutures of the stomach, then, should usually be of absorbable material and as the wall is thick, and as the action of the gastric juice may quickly disintegrate plain catgut, the absorbable suture should be well tanned or chromicized. There should always be at least two, and better, three layers of sutures. The first layer unites the mucosa with a continuous lock stitch that merely approximates the edges of the mucosa. This is No. 0 tanned or chromic catgut. The second layer brings together the muscular coats and the edges of the peritoneum on one side to similar structures on the other, using a larger size of the same suture material. The third layer is a continuous right-angle suture of 00 tanned or chromic catgut. It is well to take a back stitch at about every fourth insertion of the needle when using a right-angle continuous suture as this locks the line of sutures and prevents tension on the thread from acting as a basting suture and drawing the tissues too tightly together.

When clamps are used, however, the method of suturing the stomach with these three layers is not practicable. With clamps, as in resection of the stomach or in gastroenterostomy, the posterior borders are first united

by a peritoneal and muscular suture which is the first row that is placed. This may be of fine 00 tanned or chromic catgut and is inserted with a curved or straight needle in gastroenterostomy. In resection of the stomach for cancer, however, the healing of the tissues is at a very low ebb and it is probably wiser to use for the outer row silk or linen which will hold longer than catgut, even though there may be a chance of the unabsorbable material being retained in the wall of the stomach. When clamps are used in stomach surgery the posterior row of sutures uniting the peritoneum may be either continuous as in gastroenterostomy, or interrupted mattress sutures. The second or inner row is always a continuous suture, usually a lock stitch on the posterior wall, penetrating all coats and is snugly applied and of size No. 1, tanned or chromic catgut. After completing the posterior sutures as a lock stitch it is best to change into a right-angle stitch, penetrating all coats, and taking short bites through the whole wall of the stomach. This is drawn snugly and is continued around the anterior wall. The clamps should be slightly loosened just before the sutures are completed to demonstrate any bleeding points. The suture is tied to the original short end. The row first begun is then completed, so burying the inner row throughout. It is important to put extra sutures at each end of the incision in order to take up the strain that occurs at these points.

After gastroenterostomy the tissues of the jejunum usually have low vitality because they are subjected to unphysiologic conditions which have already been discussed. Here the acid contents of the stomach empties into the jejunum which, normally, contains only an alkaline medium. This effect may be partly obviated if the pylorus remains permanently closed, but in any event a trauma or a source of irritation at this point, such as the application of clamps during the performance of the operation, or the presence of silk or linen sutures, may be too great a burden for these tissues to carry when they are already struggling against abnormal conditions. Consequently, a suture or a trauma that in normal tissue could be readily disposed of, may cause trouble here. In other portions of the intestinal tract there seems to be but little objection to the use of unabsorbable suture material.

In the small bowel a single row of unabsorbable sutures if properly placed is safe. More than this tends to occlude the lumen of the bowel. In the large intestine because of irregularities of its external surface and the solid character of the fecal matter which produces a greater strain upon the wound, it is best to use an inner row of nonabsorbable sutures and to reinforce this by another row of sutures, preferably interrupted fine tanned or chromic catgut. All sutures for the intestine or stomach should be placed in a round noncutting needle. For resection of the small bowel a straight ordinary needle, rather long, the kind usually called a "milliner's needle," is excellent. Linen or silk is used. If silk is used it should have ample tensile strength. Linen, though somewhat rougher, is stronger than silk. The needles are threaded with a silk or linen strand about eighteen inches

long and four of these threaded needles are worked through a strip of gauze, such as a piece of bandage two feet long. This prevents tangling of the thread. The use of a thimble with a straight needle is readily acquired and adds somewhat to the efficiency of the technic. It also lessens the liability of puncturing the glove. Where the bowel cannot be readily delivered or where the amount of fat is excessive, a straight needle cannot be used satisfactorily and a curved needle is employed. The sutures are inserted through all coats of the bowel. It has been demonstrated first by W. S. Halsted that an intestinal suture that does not take at least a part of the submucosa of the intestine is unsafe and is likely to tear out. F. G. Connell showed the difficulty of catching any portion of the submucosa in the bite of the needle without penetrating to the mucosa. If the safety of the intestinal suturing is dependent upon grasping the submucosa in its bite, it would be best to be certain of this and to make an effort to penetrate to the lumen of the bowel with the insertion of each stitch.

Lambert first demonstrated the necessity of broad approximation of the peritoneal coats in intestinal suturing. The so-called Lambert's suture was originally said to be a suture of the peritoneum alone, but this is impossible. As has already been pointed out it is necessary to secure firm union, particularly if only one row of sutures is to be used, and to do this there must be penetration into the lumen of the bowel with each suture. This should be done, however, in such a manner as to invert the edge of the intestinal wound and to bring together snugly the peritoneal surfaces as called for by Lambert.

The two types of intestinal sutures are interrupted and continuous. All, of course, must embody the Lambert principle of inverting the edges of the bowel and approximating the peritoneal coat. No more of the bowel edge should be turned in than is necessary to secure a neat approximation of the wound. If too much is turned in, particularly in circular suturing, too great a diaphragm may be produced and obstruction will result. Then, an unnecessary amount of tissues is placed within the lumen of the bowel which adds to the burden of tissue repair.

Different emergencies may call for different types of suturing but, as a rule, if interrupted sutures are used they should preferably be of the mattress type. This holds with a firm grip and is not likely to cut out. There is an objection that more nutrition is cut off from the edge of the wound by the interrupted mattress sutures than by the single straight suture. If the sutures are not placed too close together and are not tied too tightly this disadvantage may be overcome. The tying of any intestinal suture is a matter of great importance. The tying of sutures in the skin or fascia may merely result in an ugly defect in that portion of the wound, but an improperly tied intestinal suture may cause leakage of the bowel with death. If the tissues are not snugly approximated, leakage may occur around the suture, but an equal or even greater danger is that if the suture is too tight and the nutrition within its grasp is completely cut off the bowel

wall will become necrotic within the bite of the suture and leakage is very apt to follow. In experimental work an operator who first attempts intestinal suturing is likely to commit the error of tying the sutures too tightly. It often happens that leakage occurs at points where he is most particular to make the suture secure and not only destroys the nutrition of the tissues but acts as a seton and drains the intestinal contents into the peritoneal cavity.

The dangers from intestinal suturing may be placed in the ratio of their importance; first, tying the suture too tightly; second, not tying the suture tightly enough; and third, turning in too much bowel. This last danger, of course, presupposes that each suture has been otherwise properly placed and penetrates into the lumen of the intestine. Occasionally, as a reinforcing stitch a simple continuous suture is all that is necessary, but if dependence is to be put on a single row of intestinal sutures, the mattress sutures, particularly the continuous mattress, offers many advantages. This is the same as the continuous right angle suture. Applied from within the lumen of the bowel, as in the first portion of suturing after a resection, it is usually called a mattress suture, but when applied from the peritoneal surface as in the later stages of suturing a resection, it is often referred to as a right angle stitch. The mechanical effect of both is identical though the technic of insertion may be different. The bite of the needle is parallel with the edge of the wound, so that the visible part of the suture on the external portion of the wound is at a right angle to the wound, hence the name.

The advantages of this type of sutures are several. First, there is a firmer grip upon the tissues. In a simple continuous overhand stitch the bite of the needle is at a right angle to the wound. Consequently, the tension on the thread is concentrated at that portion of its bite which is farthest from the intestinal wound. This concentrated tension may produce cutting. In the continuous mattress- or right-angle stitch the tension is more or less equally distributed along the whole length of the loop. It is common knowledge that in suturing such friable material as a muscle a mattress suture that distributes pressure approximately equally along the loop will hold when a straight stitch will cut out. The same principle applies here. Another advantage is that the thread is more easily buried. After a properly applied right angle suture the thread is often invisible except possibly at the beginning or end of the suture, and sometimes the knots can be buried. In the continuous overhand suture, however, there is always a considerable amount of the thread showing along the suture line. It is necessary to penetrate the lumen of the bowel in order to secure a firm hold for the sutures and the effect of capillarity must be borne in mind. A method of suturing that results in the burying of most of the thread in the peritoneal coat has obvious advantages in this respect over a method in which much of the thread is exposed and where, consequently, septic material may drain by capillarity from the lumen of the bowel to the peritoneal surface.

As a rule, a continuous suture is preferable to an interrupted though, of course, there is a field for both. The interrupted mattress suture, particularly, cuts off more nutrition from the edge of the healing wound than does a continuous mattress, because the interrupted mattress diminishes nutrition to the approximated portions of the bowel within the grasp of the suture on both sides of the intestinal wound; whereas in a continuous mattress or right-angle suture the tissue on the opposite side to the bite of the suture is free from constriction and its circulation is not impaired.

Crile has had much success with a double mattress or cobbler's stitch. This stitch should be applied with great care for if drawn too tightly it will cut off a maximum amount of nutrition from the healing wound. It gives an even support to the wound and in highly vascular tissue it is very satisfactory.

Aside from the question of nutrition further advantages of a continuous suture over an interrupted are that the former produces a mild pressure on the peritoneum along the whole surface of the approximated intestinal wound, and it holds the wound at rest like a splint. With interrupted sutures, however, the pressure is greatest in the grip of the suture, very slight in the intervals between the sutures, and there is no splint-like action. The bowel wall can distend and contract with the alternate relaxation and contraction of each peristaltic wave and this constant motion may retard healing. The action of the continuous sutures which holds the wound of the bowel as in a splint and prevents the alternate distention or contraction is a very obvious advantage in healing.

Small intestinal wounds are best treated with one or two interrupted sutures, or with a pursestring suture that inverts the edges of the wound and that can be applied in small wounds where the inversion is not sufficient to interfere seriously with the lumen of the bowel.

Wherever possible in suturing the bowel intestinal clamps should be applied at some distance from the site of operation to prevent soiling the wound. If clamps are unavailable tapes or strips of gauze may be utilized by perforating the mesentery with a blunt forceps at a short distance from the bowel and tying the tapes snugly. Care should be taken to use no more pressure than necessary to occlude the lumen. Another method is afforded through the use of hemostatic forceps which are thrust through the mesentery and a rubber tube is grasped in the tip of the forceps. The forceps are locked and the tube is fastened to the handle of the forceps in such a manner as to produce occlusion of the lumen of the bowel. Two wooden tongue depressors and electric bands may be employed.

ENTEROSTOMY

J. W. Long, of Greensboro, N. C., has been a pioneer in pointing out the life saving value of a simple enterostomy performed before the patient has become overwhelmed with the toxic products of an intestinal obstruction.

When obstruction follows shortly after operation and the resistance of the patient has already been greatly reduced, Long[1] operates after removing one or two stitches of the wound. The point of obstruction is not searched for unless it is easily reached, but the first distended coil of intestine is delivered into the wound and a pursestring suture is placed deep in the bowel wall encircling an area at least one-half an inch in diameter. The suture is caught at two points with forceps and the untied ends are grasped with the fingers. By making traction on the forceps and on the untied ends sufficient tension is made to steady the wall of the bowel and also

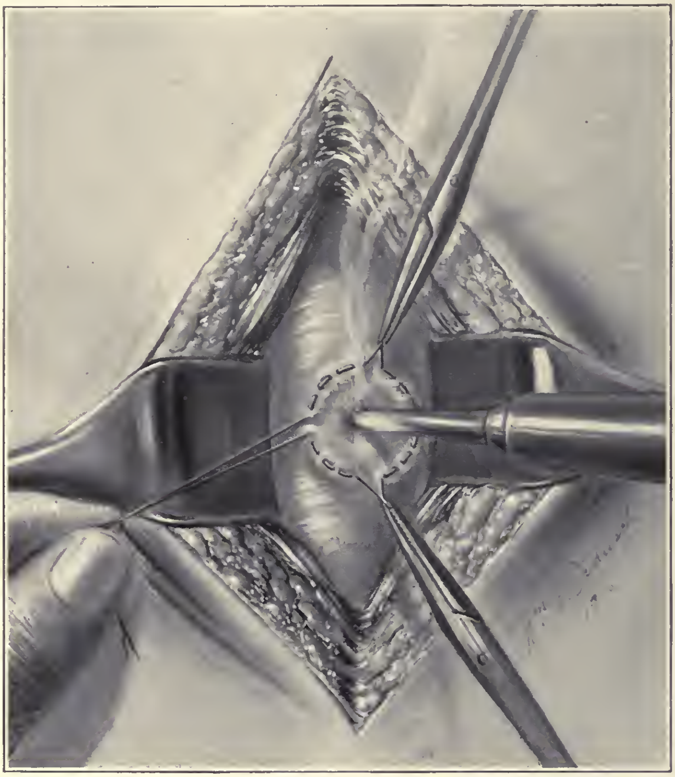

Fig. 530.—Enterostomy of J. W. Long. A pursestring suture has been placed and the bowel is perforated with the cautery.

to reduce the soiling of the field of operation. The coil of intestine is lightly packed around with moist gauze and while the ends of the suture and the two forceps which grasp the other portion of the suture are held taut, the center of the area that is circumscribed by the pursestring suture is perforated with a thermo cautery (Fig. 530). This prevents bleeding and seals the various coats of the intestine together. It also prevents a tendency to eversion of the mucosa which occurs after an incised wound.

[1]Tr. Southern Surg. Assn., xxix, p. 59, et seq.

A tube, which should be ready, is inserted immediately after the cautery point is withdrawn. The tube is of fairly soft rubber that will not readily collapse and should be about twice the size of the opening. It is introduced with forceps, stretching the perforation if necessary, and fits so snugly that there is no leakage around it. The two forceps are removed from the pursestring suture and the ends of the suture are tied snugly after

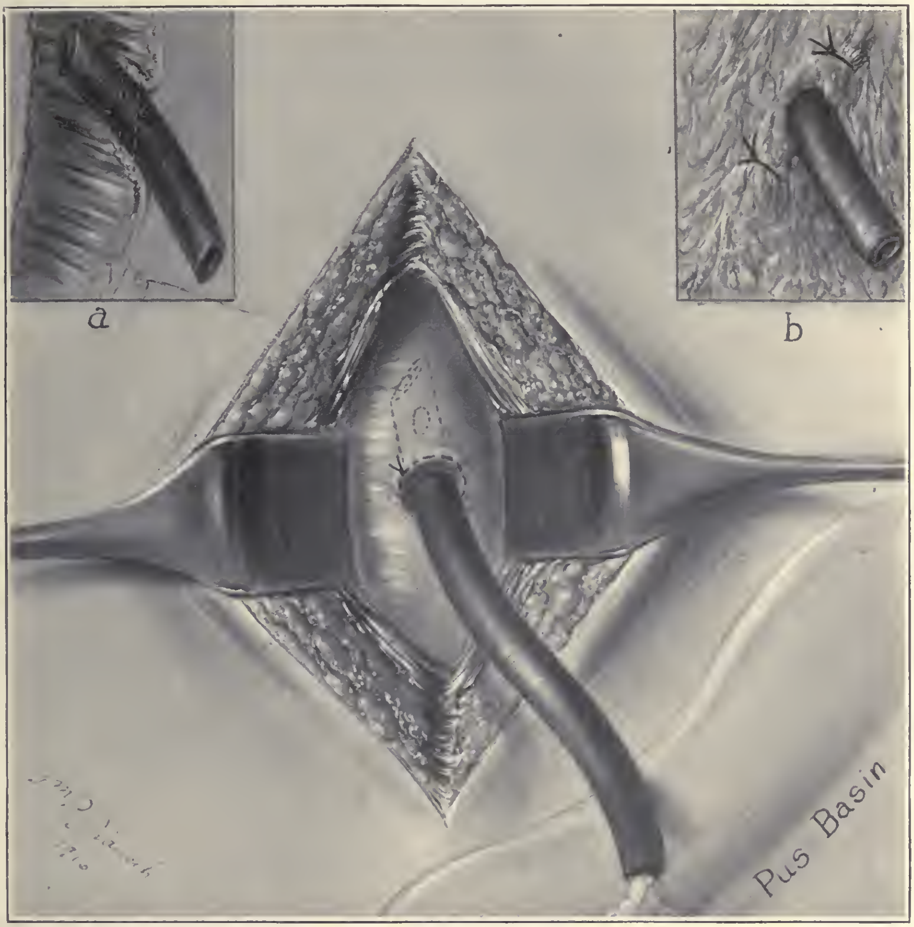

Fig. 531.—A rubber tube is introduced and held snugly by a pursestring suture. Insert *A* shows a cross section of tube in position, and insert *B* shows omentum sutured around the tube (J. W. Long).

carefully inverting the edges of the perforation. Sometimes a second pursestring suture may be added, as in the Senn gastrostomy. If omentum is present it is either drawn around the tube and held in position by a few catgut sutures, or a hole may be torn in it and the tube brought through the omentum which is fastened to the bowel on each side of the tube (Fig. 531). He objects to fastening the tube in position by suturing it to the bowel wall, for he says that the suture will cut through the bowel wall, increase the size of the opening into the intestine, and make the fecal fistula

more difficult to close by promoting eversion of the mucosa. Long fastens the tube by narrow strips of adhesive plaster from the tube to the skin. (Fig. 532). The open part of the abdominal wound is lightly packed with gauze. Sometimes the loop of bowel may be anchored to the parietal peritoneum by two or three interrupted sutures, but this is not always necessary.

When the operation does not admit of the delivery of a coil of intestine into the wound the operation of J. W. Long is an excellent one and has many advantages. When the bowel can be readily delivered and packed off, I prefer an operation based on a principle established by

Fig. 532.—The wound is packed lightly with gauze and the tube fastened with adhesive plaster (J. W. Long).

Coffey of making a valve of the mucosa of the bowel, so that when the tube is withdrawn there will be but little if any leakage. A distended loop of bowel is delivered into the wound, clamped at one end with intestinal forceps, stripped of its contents, and again clamped at a point about six inches from the first intestinal forceps. The convex border of the intestine is grasped with mosquito forceps or with Allis forceps about two inches from one of the clamps and another point is similarly caught two inches from the other intestinal clamp. The forceps holding these two points are pulled upon just enough to make the bowel between them taut, and a two inch in-

cision is made in the axis of the bowel between them. This should be made with a sharp knife and care must be taken not to cut through the mucosa. After separating the peritoneum and the superficial part of the muscular coat of the bowel the edges of the incised wound are pushed apart with the handle of the knife or by dissecting with the blade of the knife turned sidewise to the plane of dissection, which is a stroke often employed in operations on the neck and in anatomical dissections. In this way, even though the bowel wall is thin, injury to the mucosa can usually be avoided. Considerably more care must be taken, however, to avoid injury to the mucosa than in making a similar incision into the stomach. If the mucosa is injured at either end of the incision but little harm is done. If, however, it is injured at its middle, the incision should be extended slightly

Fig. 533.—Enterostomy, using the principle of Coffey. An incision is made down to the mucosa. At one end of the incision a pursestring suture is inserted and the mucosa is punctured.

at one end in order to secure a sufficient amount of exposed mucosa to form a valve. If the mucosa has not been injured and has been exposed over a distance of about two inches, a pursestring suture of linen or silk is placed at one end of the incision including the terminal part of the mucosa within its grasp. The bowel is steadied by the ends of the pursestring suture which are not tied and by forceps which grasp the suture opposite its ends. With a sharp-pointed knife a small puncture is made in the mucosa contained within the grasp of the suture (Fig. 533). A soft rubber catheter of medium or large size, which has one or two extra perforations near its tip, is inserted through the punctured wound until the upper perforation in the catheter is at least an inch within the bowel. The pursestring suture is then tied snugly around the catheter and

a curved needle is threaded into one end of the suture and thrust through the catheter, the ends of the suture being again tied. In this manner the catheter is held snugly in position and will not be dislodged for several days (Fig. 534). It is then laid on the bed of mucous membrane which has been prepared for it and one or two rows of continuous right-angle sutures of silk or linen bury the catheter effectively (Fig. 535).

The catheter may be brought through a stab wound. If this is done, it should have been clamped about its middle before it was inserted in the bowel to prevent fecal material flowing through it and contaminating the stab wound. The clamp on the middle of the catheter is removed after its end has been brought through the stab wound. If the operation is for postoperative obstruction and the loop of bowel is delivered into the wound previously made,

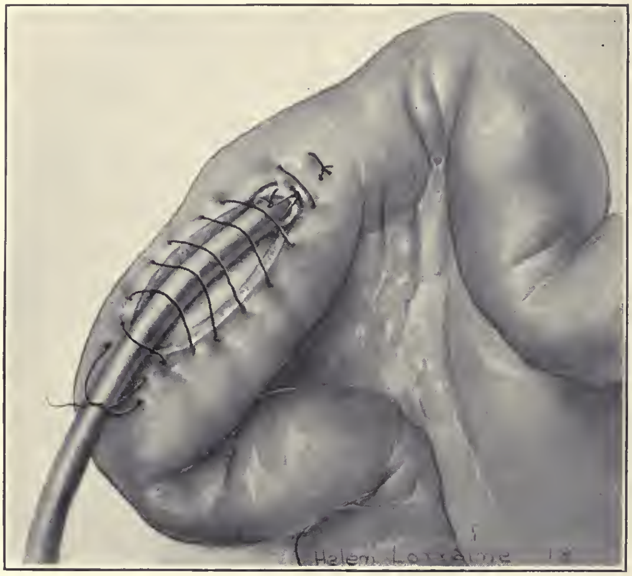

Fig. 534.—A catheter is inserted in the puncture and the pursestring suture is tied snugly. One end of the pursestring suture is threaded on a sharp needle and fixes the catheter in position. The portion of the catheter that lies on the incision is buried with a right angle stitch.

the catheter may be connected with a larger rubber tube which conducts the discharges into a receptacle. If omentum is readily accessible it may be sutured around the tube but this is not necessary. A tube sutured in the manner described with linen or silk will remain in position from six to ten days. Although fastened securely by the pursestring suture it practically always cuts loose within ten days, so if it is desired to prolong the drainage from the enterostomy the catheter must be either fastened to the skin by a suture, or, better still, by adhesive plaster strips, as practiced by Long. In any event it should be anchored to the dressing so that there may not be any pulling on the suture through traction on the tube.

Coffey has well established the principle of preventing back pressure

from the abdominal viscera, as when transplanting a ureter in the bladder or the bile duct in the intestine, by making an incision down to the mucosa and then inserting the duct or the ureter at one end of the incision so that it is buried in the wall of the viscus and only separated from the interior by the thickness of the mucosa for the length of the incision. In this way distention causes the mucosa to press against the transplanted duct and to protect its lumen from the direct effect of pressure to which it would otherwise be subjected. The advantages of using this method of enterostomy are that it does not materially prolong the operation, and when the patient has recovered from the effects of the obstruction and the catheter is withdrawn there is practically no drainage of fecal matter through the tract left by the catheter. Sometimes a small amount of fecal drainage occurs for a few days, but usually there is none. This, of course, is a great

Fig. 535.—The enterostomy is completed. Usually there is no leakage of fecal matter when the catheter is withdrawn, due to the valve formation of the mucosa.

advantage over the older method of a large opening with eversion of the mucosa and a fecal fistula difficult to repair.

The fecal matter in the small intestine is always liquid and is usually liquid in the cecum and in the right half of the colon. The formation of gas in the bowel is one of the most distressing features of obstruction and by producing great intraintestinal pressure undoubtedly forces into the lymphatics or the veins of the intestines toxic products that might not otherwise be absorbed. A medium sized rubber catheter will give ready exit to the gas and the liquid fecal contents of the small intestine, and a somewhat larger catheter would be amply sufficient for the cecum and ascending colon. A large tube can do no more than empty the bowel, which the smaller catheter does. The large tube produces more trauma, may be followed by the necessity of clos-

ing the opening by a later operation, and also may encroach too greatly upon the lumen of the bowel after the obstruction has been overcome.

The principle of Witzel is essentially different from that of Coffey. If the bowel is greatly distended and it seems impossible to free the mucosa without injuring it, a tube may be inserted according to the principle of Witzel. Here the wall of the bowel is punctured to admit the tube, which is fixed in position, as has been described. Then the bowel wall is folded over the tube and sutured (Fig. 536). A cross-section will show that this channel is composed of all the histologic layers of the bowel wall. Consequently the peritoneum, which lines the tunnel and readily forms a lymphatic exudate, will make a rigid tube of the tunnel in which the catheter has been laid, so that after the catheter has been withdrawn leakage of fecal matter is much more likely to occur. Besides, there is more encroachment upon the lumen of the bowel by the Witzel principle which folds in all

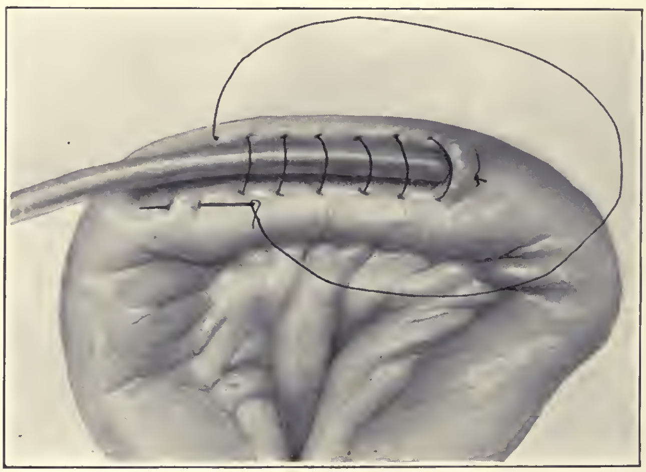

Fig. 536.—Enterostomy according to the principle of Witzel without an incision to the mucosa.

layers of the bowel wall than by an operation performed on the principle of Coffey in which the catheter lies on the mucosa and the mucosa forms a valve (Fig. 537-A and B). There is but little exudate from the mucosa and the peritoneum does not enter into the floor of the tunnel of an enterostomy performed in this latter manner, so but little lymphatic exudate is thrown out and when the catheter is withdrawn the mucosa is mobilized and the intraintestinal pressure quickly closes the tunnel.

This operation is done not only in obstruction but after resection of the bowel, as in strangulated hernia, when the oral portion of the intestine is greatly distended. After the resection, an enterostomy, as just described, is done on the proximal side of the resection, the catheter having been previously introduced through a stab wound and its distal end clamped before the catheter is inserted into the bowel. This avoids infection of the wound. An enterostomy in such cases has a very valuable function. It

drains off the contents of the obstructed bowel and lessens the pressure on the healing intestinal wound where the resection was done. Peristalsis is always interfered with in obstruction, even when a resection has been carefully performed. The peristalsis may be so weak that it cannot take advantage of the removal of the obstructing or gangrenous loop sufficiently to propel the contents of the dilated bowel through this newly sutured area. The enterostomy tube, however, gives immediate exit to the gas in its neighborhood and offers much less resistance to the passage of intestinal contents than would occur if the fecal matter had to be propelled through its normal route. Consequently, weak peristalsis that is sufficient to empty the contents of the bowel through a soft rubber catheter that is contained in an enterostomy wound, may not have force enough to overcome the normal physiologic resistance of the rest of the intestinal tract even though the immediate obstruction has been removed.

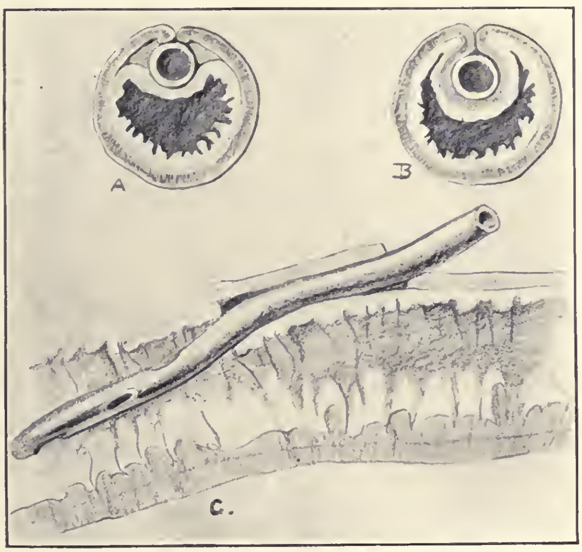

Fig. 537.—*A*, a cross section of enterostomy, using the principle of Coffey; *B*, a cross section of enterostomy, using the principle of Witzel; *C*, longitudinal section of enterostomy, using the Coffey principle.

If liquid feces does not flow sufficiently freely through the enterostomy tube an ounce or more of warm water is injected through the catheter into the bowel. This will prevent the closing of the openings in the catheter by the mucosa of the bowel or will cause the dislodging of any large particles of fecal matter that may occasionally obstruct the opening in the catheter. This, however, should not be done as a regular practice for it may stimulate the loop of bowel that contains the enterostomy tube to strong peristaltic contraction. When peristalsis has become normal, which usually occurs within a week or ten days, and one or more bowel movements have been secured through the anus by enemas, the enterostomy tube can be safely removed.

It is an old saying that obstructed bowel should never be returned to the abdomen until it has been thoroughly emptied. This is an unwise practice and has been responsible for the introduction of glass or metal tubes through an opening in the bowel and the threading of almost the whole length of the small intestine on such a tube in order to empty the fecal contents as far as the upper jejunum. This practice tends to disregard the physiology of the intestines, and particularly the physiology that occurs after obstruction. It is well known that even the opening of the abdomen under a general anesthetic is followed by temporary paresis of the bowels. This is probably a protective phenomenon which is intended to keep the bowel quiet so that a neighboring loop or omentum may plaster over an injured portion of the intestine and prevent infection. It also provides physiologic rest for repair. At any rate, the phenomenon is commonly observed and is more pronounced with increased handling of the viscera. If, then, the whole length of the small intestines is forcibly threaded over a rigid tube it can readily be imagined that the normal reaction would be a complete abolition of peristalsis for a considerable time. This paralysis of the bowel wall will do much more harm in permitting the rapid accumulation of gas and fecal contents than the immediate emptying by such mechanical means will do good. If the obstruction has reached such a stage that peristalsis is completely and permanently abolished nothing can save the patient, but if there is still preserved a weak peristalsis the performance of an enterostomy, such as has been described, with exposure of a single loop of bowel, will relieve the immediate obstruction in this loop and will tend to encourage the emptying of other proximal loops that still have sufficient peristalsis to expel their contents when both the pathologic and physiologic obstruction has been overcome by the enterostomy. But if the whole length of the bowel has been forcibly threaded over a stiff metal or glass tube the manipulation of the intestine will in all probability completely abolish the weak effort at peristalsis that still remains. It is in such cases that an enterostomy with a rubber catheter performed above the point of obstruction gives the maximum chances for recovery.

Whether the diseased loop of bowel is to be removed at the same time the enterostomy is done depends upon the pathology that is present. If the bowel contains a tumor that has caused the obstruction the enterostomy should be performed as the first operation and resection done later, after the effects of the obstruction have been overcome. If gangrene or perforation is present or seriously threatens the loop of diseased bowel should be removed and an enterostomy done on the proximal side of the diseased loop according to the technic that has just been described. If there is a tumor in the transverse or descending colon or sigmoid and the obstruction occurs from this growth, an enterostomy is best done in the cecum. The tumor should be removed at a subsequent operation, probably ten days or two weeks later.

An enterostomy according to the technic described should not be done with the idea of giving complete rest to the bowel distal to it. If there are multiple ulcerations in the colon, without obstruction, and the purpose of the operation is to rest the colon by diverting the fecal matter, but little good is accomplished by an enterostomy that will not divert all of the fecal con-

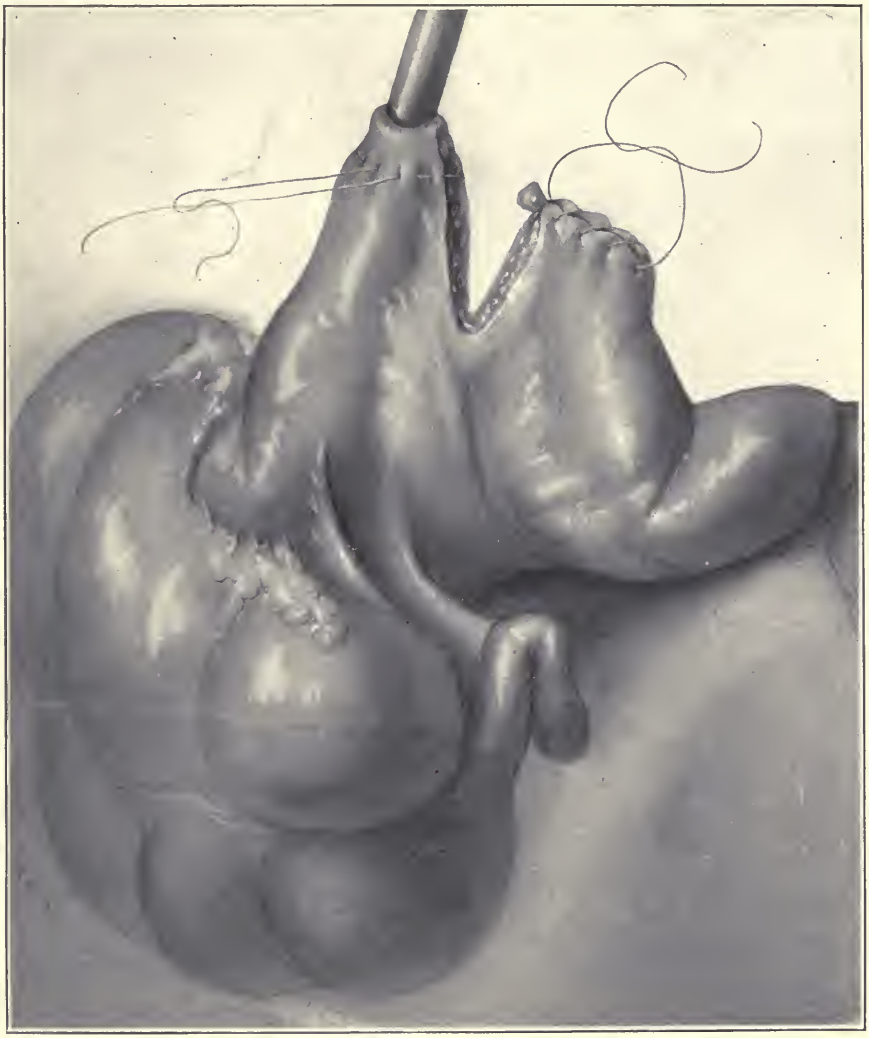

Fig. 538.—The enterostomy of John Young Brown, with a slight modification as explained in the text. The proximal end is temporarily sutured till the distal tube is fixed. The sutures may then be reversed and a tube inserted, or this may be done two days later.

tents. Here the operation may be performed either on the right side, using the terminal ileum according to the method of John Young Brown, or on the left side above the growth, using the sigmoid. The bowel is completely divided in either instance.

In the operation of Brown an incision is made in the right iliac fossa. It may be a muscle-splitting incision according to the McBurney technic.

The cecum is recognized and the lower ileum is pulled into the wound. Brown originally advised section of the ileum close to the cecum, and when the continuity of the intestinal current was reestablished it was necessary to implant the ileum into the cecum or ascending colon by an end-to-side operation. In this way the action of the ileocecal valve is lost. By selecting a point for division of the ileum about eight inches from the ileocecal valve, the future union of the ileum by the end-to-end method is possible and the action of the ileocecal valve is preserved. The mesentery is first split for about an inch from the bowel wall. The bleeding vessels are controlled by liga-

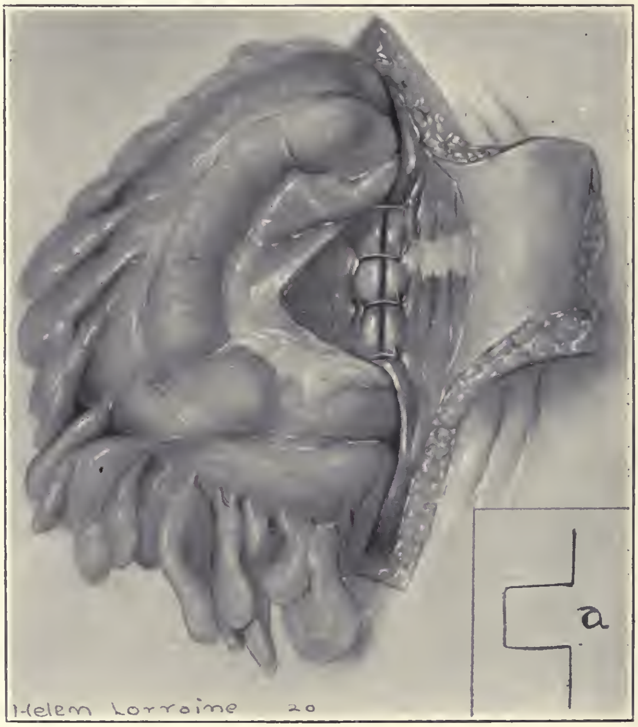

Fig 539.—Sigmoidostomy according to the method of Mixter. Insert *A* shows the lines of incision to secure a bridge of skin beneath the sigmoid.

tures or sutures which cover the raw surfaces as fully as possible before opening the ileum. Intestinal clamps are placed on the bowel near the line of division and the ileum is severed with scissors, cutting from the mesenteric border outward. In this way the chances of infection of the mesentery and of the triangular space where the mesentery separates to involve the bowel are reduced to a minimum. In the lower end of the ileum a large-sized rubber catheter is fastened by suturing it to the bowel. The catheter should reach through the ileocecal valve into the cecum. A purse-string suture inverts the edges of the stump of the ileum around the catheter as in operations on the gall bladder (Fig. 538). This tube is clamped. It is

only used to irrigate the colon with some fluid that is supposed to have a therapeutic value. In the upper end of the bowel a larger tube, preferably a rectal tube, is inserted in a similar manner and is connected to a receptacle. The bowel ends are attached to the parietal peritoneum by a few sutures and the wound is packed lightly with iodoform gauze. The tube in the distal end of the bowel is readily kept in position almost indefinitely but the sutures around the proximal tube through which the fecal matter runs soon cut out and leakage occurs at this point within a few days. During this time, however, granulations have sprung up and the raw surface of the abdominal wound has acquired some protection against the septic products of the bowel contents. An advantage that Brown mentions for this operation is that there

Fig. 540.—Sigmoidostomy with the bridge of skin sutured in position. The sigmoid is opened and a tube inserted for immediate relief of obstruction.

is less odor than when an enterostomy is made in the large bowel, but the great advantage is that it completely diverts the fecal current and it so rests the portion of the intestinal tract distal to this enterostomy as to give it the best possible opportunity for recovery.

In inoperable cancer of the rectum often a permanent enterostomy must be done. Here the sigmoid offers a satisfactory site for the operation and the method of Mixter gives good results. An incision is made along the outer portion of the left rectus muscle and is so fashioned that a small tongue or flap of skin and subcutaneous tissue is formed from the middle of the incis-

ion with the base outward (Fig. 539-A). After dissecting up this flap with the skin and fascia and turning it outward, the fibers of the rectus muscle are split, the peritoneum is divided and the sigmoid delivered into the wound. All the excess of the sigmoid is shoved up into the abdomen so that as little of the bowel is left below the eviscerated loop as possible. In this way a reservoir for fecal matter is established. The mesentery of the sigmoid is split for about two inches at right angles to the long axis of the bowel, and the rectus muscle and peritoneum are sutured together through this opening in the mesosigmoid (Fig. 539). The reflected flap of skin and fascia is brought through this opening and is sutured in its original position. In this manner the loop of sigmoid that has been delivered rests upon the

Fig. 541.—Several days after the first stage of the operation, the bowel is divided or a section is removed, leaving an upper and a lower opening.

flap of skin and fascia which has been sutured under it (Fig. 540). If the need is urgent an enterostomy can be done with a rubber catheter as has been described, but if the obstruction is not complete or if a temporary enterostomy is done, five or six days later the exposed loop of sigmoid is completely divided and the bleeding points are controlled by whipping them over with a needle and thread (Fig. 541). The two ends retract and are sufficiently wide apart to make a complete break in the fecal current. At the same time the distal end of the sigmoid can be utilized for irrigations to clean out the rectum.

INTESTINAL RESECTION

When resection of the bowel is indicated the technic to be adopted varies somewhat, depending upon whether the large or the small bowel is involved, but the same principles that underlie this operation are applicable wherever resection is employed.

The type of suture and the advantages of a continuous mattress or right angle stitch that penetrates all coats of the intestine have been described. The two operations usually employed for uniting the bowel after resection are the lateral or the end-to-end, with an occasional end-to-side anastomosis.

As elsewhere in surgery the object of an operation should be first of all to remove or to correct the pathology and, second, to restore the tissues as nearly as possible to their physiologic normal. Lateral intestinal anastomosis does not fulfill this latter indication. The work of Cannon and Murphy[2] has shown that in lateral anastomosis peristalsis in the region of the anastomosis is practically abolished and food can be pushed through the anastomotic opening only when a column of it extends into a proximal (oral) loop where peristalsis is unimpaired, because severing the circular muscular fibers in lateral anastomosis abolishes peristalsis and the blind pouches at the ends cannot be completely emptied. These investigators also found that in end-to-end union there is not the slightest stasis of intestinal contents at the site of operation. Many patients with a lateral anastomosis are able to overcome the handicap of an unphysiologic procedure and have no symptoms from lateral anastomosis. This, however, is by no means always true, and the cases reported by John T. Moore,[3] of Houston, and many others, show that the complications following lateral anastomosis may be extremely serious.

It seems established and admitted that an end-to-end union of intestine is a more physiologic procedure than a lateral anastomosis and other things being equal would be the preferable operation. Because lateral anastomosis does not always give disagreeable symptoms its use has been continued. If the patient did not die it was assumed that he had sufficiently recovered. Similarly, it may be claimed that a perfectly compensated valvular lesion of the heart is of no significance because it gives the patient no inconvenience and causes no symptoms, for nature can often take up a burden that has been imposed and compensate for it in such a manner that the patient does not suffer.

The argument against end-to-end union of the intestine has been that the suture line is likely to leak either at the mesenteric junction with the bowel or at a point opposite to this where the nutrition is poor. I[4] have attempted to show in previous communications that while the triangular space where

[2]Cannon and Murphy: Ann. Surg., xliii, 519-520.
[3]Tr. Southern Surg. Assn., xxxi, pp. 152-153.
[4]Ann. Surg., xxxviii, 747; Southern Med. Jour., viii, p. 298; Surgery of the Blood Vessels, St. Louis. 1915, C. V. Mosby Co., p. 204.

the mesentery splits to envelop the bowel has been considered responsible for most of the failures of end-to-end union of the intestine, and while it has been assumed that because this space is devoid of peritoneum union here is difficult and leakage probable, the real cause for failure is not the absence of peritoneum in this region. W. J. Mayo has repeatedly stated that peritoneum is only needed on one side and this mesenteric space is usually carefully sutured by every operator before the operation is completed. The great trouble is that many surgeons who have had disastrous experience in end-to-end union infect this triangular area when the lumen of the bowel is opened by cutting the bowel from the convex border toward the mesentery and then clamping and suturing the triangular space between its layers. Dividing the bowel in this manner necessarily carries the contents of the bowel into this triangular space because the blades of the scissors that cut through the lumen of the bowel must be contaminated with fecal contents and smear the bacteria from the lumen of the bowel into this space. When the operation is completed this region is carefully sutured and later when leakage occurs here, it has been assumed that the leakage is due to the lack of peritoneal covering. If we were to dip a platinum loop into fecal contents, smear it into an incised wound on the hand, and then later suture the wound very carefully, we would not be surprised when the sutures broke down. It is for the same reason that leakage occurs at the mesenteric triangular space which is composed largely of areolar tissue rich in lymphatics and small blood vessels, and which once infected can hardly be sterilized.

The question of infection in intestinal wounds is closely allied to the nutrition of the wound. If the infection is mild and in a region such as the free border of the intestine where there is no areolar tissue, the infection may be overcome if the blood supply to that part of the bowel has not been impaired.

To avoid infection or to render it as mild as possible the ends of the bowel should be cleaned. This should be done with great care, using gauze wrung out of antiseptic solution, and making an effort to clean the mucosa of the intestine as we would disinfect the skin before making an incision into it. It may be impossible to sterilize the mucosa of the intestine just as it is impossible to sterilize the skin by any known method that does not destroy the skin, but certainly the majority of the bacteria can be removed, and then the needle and thread will not carry the infection as they do if the fecal matter is simply squeezed out and no further effort is made to clean the bowel end. Leakage opposite the mesenteric border in end-to-end union of the colon may be due to lack of cleaning the bowel end with antiseptic solution, so preventing infection where the nutrition is weakest. If the end of the bowel, and particularly of the colon, is not made as nearly aseptic as possible, when the thread pierces its lumen it carries bacteria through the whole tissue. This may account for the poor healing and the late infection of the stitches that have sometimes been noted after resection of the

colon. If the end of the bowel is clean fecal matter when turned on after removing the intestinal clamps will only contaminate that portion of the thread within the lumen and there is less chance of infection from the thread that is already buried in the tissues of the bowel.

The chief objections, then, that have been urged against end-to-end union are: first, infection or leakage at the mesenteric border and, second, infection or leakage at a point opposite to the mesenteric border. The cause of leakage at the mesenteric border has been shown to be soiling of this region by the technic of cutting the bowel from the convex border into the mesentery. Leakage opposite the mesenteric border or elsewhere, when the sutures have been properly placed, is probably due to the fact that the ends of the bowels have not been thoroughly cleaned and the suture drags along with it the bacteria of the fecal contents.

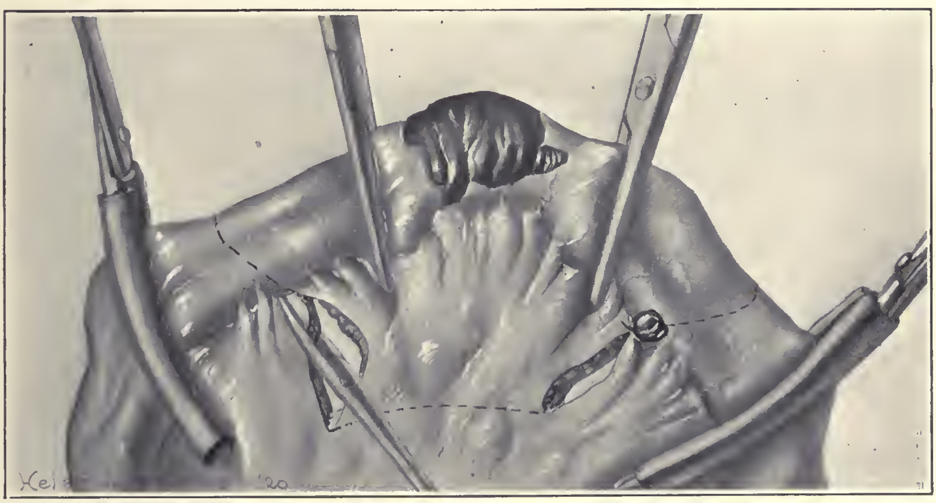

Fig. 542.—The author's method of intestinal resection. Before the bowel is divided, the mesentery is cut close to the bowel wall and the triangular space caused by the separation of the layers of the mesentery just before they cover the bowel is clamped and tied. The rest of the mesentery is then severed and tied, and moist gauze packed under the loop of bowel. The bowel is divided somewhat obliquely from its mesentery border outward.

In an effort to obviate these difficulties a technic for end-to-end union of the bowel has been developed in experimental work and employed clinically in many cases with great satisfaction. The method when applied to the small bowel is as follows: The segment of bowel to be removed is delivered into the wound and surrounded by moist gauze. An intestinal clamp is placed at a point about four inches from the intended line of resection. The contents of the bowel loop are stripped out as far as possible to a point about four inches beyond the other line of resection, where another intestinal clamp is placed. The mesentery is then doubly clamped, divided, and tied. The triangular space where the mesentery joins the bowel is clamped with hemostats and tied with silk or linen (Fig. 542). The rest of the mesentery may be tied with catgut. If the operation is not for removal of a malignant

tumor the mesentery is cut rather close to the bowel. This step avoids any possibility of injuring vessels that may carry nutrition to the healthy intestine. If there is a suspicion of malignancy the mesentery should be cut farther away, but care is taken to preserve as many of the blood vessels that supply the healthy bowel as possible. If the operation is for gangrene, and particularly if it is for thrombosis of the arteries, great care must be taken to make a sufficiently wide excision to secure bowel that will bleed freely. Many disasters have occurred from making resections too close to the apparent disease. Aside from the application of a few extra sutures to the mesentery there is no more difficulty in taking out six feet of intestine than six inches, and while, of course, the relation of nutrition to the length of the bowel should be considered, at least a third of the total length of the small bowel can be removed without seriously interfering with nutrition.

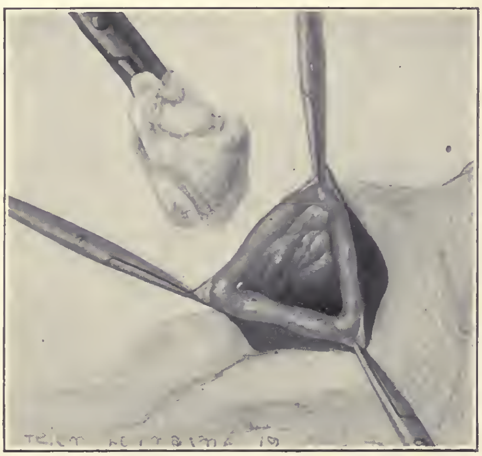

Fig. 543.—The margins of the bowel are caught with clamps and the intestinal end is cleaned with wet gauze.

It is highly important, then, to see that the resection is made at a point where the blood supply is unimpaired.

After severing and ligating the mesentery and clamping and tying the triangular mesenteric space, a quantity of moist gauze is packed under the loop that is to be removed, but which up to this time has not been opened. The loop is collapsed because its contents have been emptied before placing the intestinal clamps. A pedicle forceps is placed on the loop of the bowel as close as possible to the line of resection. The bowel is divided with scissors, beginning at the mesentery at the point where the triangular space has been clamped and tied and going upward, slightly inclining toward the healthy bowel so it will not be deprived of its blood supply. This incision should be made quickly and moist gauze should at once be placed over the end of the diseased loop. Three or four Allis forceps or mosquito forceps grasp the margins of the healthy end of the bowel at about equidistant points. The end of the bowel as far as the intestinal clamp is

thoroughly cleaned with gauze sponges that have been dipped in bichlorid solution, while the forceps that have been placed along the edge of the severed bowel hold the lumen open (Fig. 543). This cleansing should be done by the surgeon while the assistant holds the forceps, and great care is taken to see that every wet sponge that is used to clean the bowel touches nothing but the bowel end and that the used sponge is immediately deposited in some basin or bucket which is a container for dirty dressings. When all the fecal matter has been removed by gentle sponging, the excess of bichlorid is mopped out of the end, and it is covered with a gauze pad wet in salt solution, after clamping and tying with catgut any bleeding points along the cut margin. The clamping of these points may be done immediately when the bowel is cut, but they should not be tied until after it has been cleaned. Whipping the bleeding points over with catgut in a needle is more satisfactory than simple ligation which in their region often loosens.

Fig. 544.—The first stitch begins in the end of the bowel on the operator's right, about one-third of an inch from the mesenteric border, and is tied as a mattress suture. It is continued along the mesenteric border of the bowel as a continuous mattress suture.

The other end of the loop to be excised is severed in a similar manner and the other end of the healthy bowel is similarly cleaned.

Suturing is begun with a straight needle and linen thread, inserting the needle from the mucous membrane of the right-hand bowel end about a third of an inch external to the mesenteric border. The needle is carried to the other bowel end and pierces it from the peritoneal surface toward the mucosa returning in an opposite direction. It is then carried to the end of the bowel from which the suture started and is thrust through from the peritoneal surface to the mucosa. A knot is tied, which makes a mattress suture with the knot on the mucous membrane (Fig. 544). The short end of this thread is clamped with a hemostat and the suture is continued by carrying it back and forth across the mesenteric border of the intestine after the manner of a continuous mattress stitch. It should grasp a portion of the ligated triangular mesenteric space on each side to prevent the possibility

of the mesentery retracting at this point. As the bowel and mesentery are thicker than the layers of the bowel elsewhere it is essential to draw these structures more snugly together than in the other portions of the bowel. After about one-third of the circumference of the bowel has been sutured the needle is thrust through the bowel from the lumen of the right-hand end (from

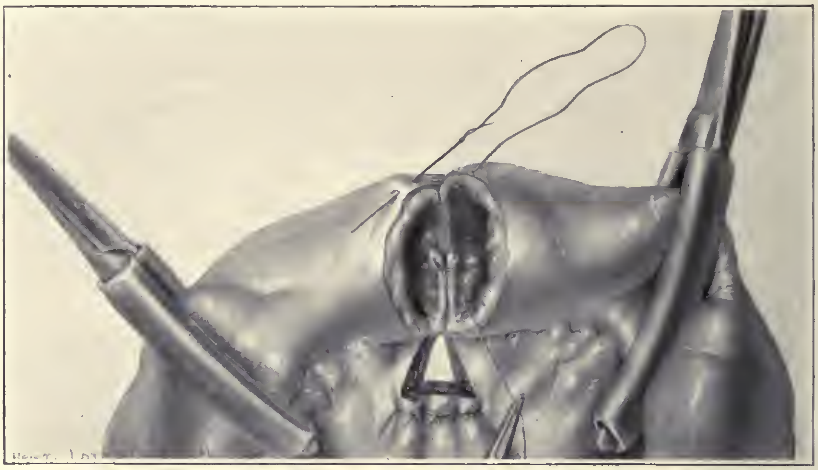

Fig. 545.—After about one-third of the circumference has been sutured, the needle is thrust through the bowel from within outward. A back stitch is taken and the suturing is continued as a right angle suture, penetrating all coats.

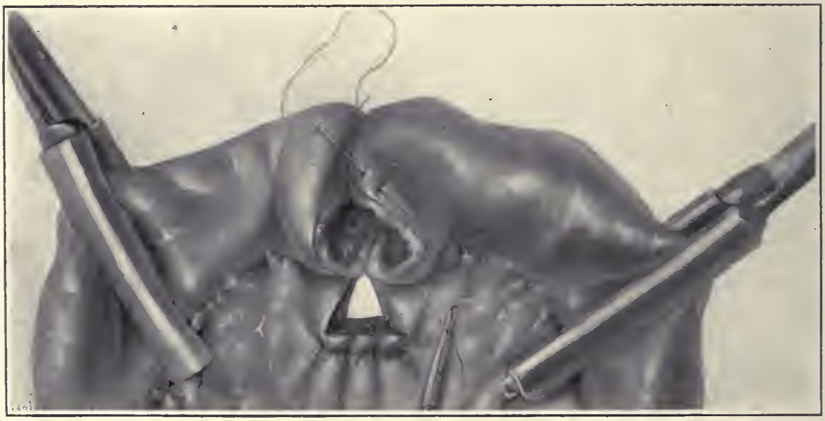

Fig. 546.—This suture is continued as a right angle suture, turning in a small margin of the bowel and taking a back stitch about every third or fourth suture.

the standpoint of the surgeon), which is the end containing the first knot (Fig. 545). After emerging by being thrust through from the lumen to the peritoneal coat, a back stitch is taken by merely taking two stitches at practically the same point. This locks the row of sutures that has been placed so far, and it is then continued as a right-angle continuous suture penetrating all coats (Fig. 546). The suture is carried about a sixth of an inch from the incised peritoneum along the margin of the intestinal

wound. If more than this amount of bowel is turned in there will be too much diaphragm. Only enough peritoneum is inverted to make a secure approximation. At about every fourth insertion of the needle a back stitch is taken by taking two sutures in the same place, or the last stitch just behind the preceding one. This prevents the thread from being drawn too tightly and so diminishing unduly the caliber of the bowel. The bowel is approximated just snugly enough to have apposition and without the tension used in the mesenteric portion. As the bowel has been cut somewhat obliquely the suturing cannot cause too much diminution of the lumen unless it is drawn too tight or unless too great a diaphragm is turned in. The evils of these two errors have already been discussed under the head of intestinal suturing. The suturing is continued toward the operator and is carried one stitch beyond the lowest point where the original thread was left when the knot was tied (Fig. 547). This last stitch is on the left-hand end of the bowel, the knot being in the other end. The thread is then firmly tied to the end that was caught in a hemostat at the beginning of the

Fig. 547.—The last stitch is taken in the left end of the bowel, slightly beyond the lowest point where the original end of the thread comes out. It is tied snugly to the original end three or four times and the ends are cut short.

suturing. The knot is run down parallel to the line of suturing so as to sink in easily and is tied snugly three times. It is then cut short and the ends should disappear in the bowel or should be tucked in with mosquito forceps. If a back stitch has been taken at proper intervals there is no danger of reducing the lumen by tying this knot too tightly, but, as has already been pointed out, if it is tied too tightly it may cause leakage from necrosis.

When the suturing is begun, the gauze that has been laid on the stumps of the mesentery and beneath the bowel loop to be resected must be removed in order satisfactorily to approximate the ends of the bowel when the first knot is tied. If there are weak points along the suture line an extra interrupted suture may be inserted, but this should be avoided by careful attention to the sutures as they are placed, for an extra stitch turns in an additional amount of bowel, makes a broader diaphragm, and places an extra burden upon the tissues at this point.

The severed mesentery is approximated with a continuous suture of plain or tanned catgut in a round needle, taking care to avoid injury to any blood vessel and securing only a slight hold along the edges of the incised mesentery. The bowel is sponged with salt solution and, if there is no marked distention on the proximal side of the resection, the intestine may be returned to the abdominal cavity and the wound closed without drainage. If, however, there is marked distention an enterostomy should be done two inches to the proximal (oral) side of the resected bowel to relieve the tension on the sutures and to secure an early and easy emptying of the bowel contents.

If the cecum and ascending colon are resected, the anatomic and the physiologic conditions are somewhat different from what is found in the small bowel. Here it is necessary to unite bowel of unequal caliber and of different gross anatomical structure. It is also desirable, as has been pointed out by Kellogg and others, to reproduce a valve like the ileocecal valve whenever the small intestine is united to the colon. It has been the common experience that when union of small intestine to the colon is made without a provision of this kind the small bowel usually dilates or thickens. This is probably due partly to infection from the colon and partly to the back pressure of gas in the large intestine. While, of course, such a valve cannot prevent the entrance of a small amount of the bacterial flora from the colon, it may act as an ileocecal valve and protect the small bowel from an overwhelming amount of colonic fecal matter which would otherwise flood the ileum with each retrograde peristaltic wave. Resection of the cecum and ascending colon is done by a modification of the technic used for resecting the small bowel. The same principles of avoiding infection of the mesenteric spaces and of cleaning the bowel ends are employed. Even greater care should be taken when the colon is involved because of the large amount of bacteria always present.

The first step is a thorough mobilization of the cecum, ascending colon, and the lower part of the ileum. This is obtained by dividing the peritoneum to the outer side of the mesentery of the cecum and ascending colon and retracting the large bowel toward the midline. The mesentery which supplies the segment to be removed is divided, taking as much as possible of it in malignancy, but being careful not to interfere with the blood supply of the ends of the bowel that are to be united after resection. The transverse colon may be clamped after making an opening in the gastrocolic omentum to insert one blade of the intestinal clamp. This gives a sufficient stump of the right half of the transverse colon to permit the necessary manipulations during suturing. After severing the mesentery and securing the triangular area, as has been described in resection of the small bowel, the ileum is divided first, because this end is probably less septic than the colon. The severed end of the loop is covered with moist gauze and the oral end of the ileum is cleaned. The distal end of the loop is divided by first clamping the colon, protecting thoroughly the tissues in the neighborhood with moist gauze, and then severing the bowel from the mesenteric border outward. The edges of the stump of the

transverse colon are caught as the loop is severed in order to hold up the stump of the bowel and prevent leakage of its contents. This end is thoroughly cleaned. Suturing is begun with a straight needle and linen thread beginning on the mucosa of the colon. The needle is carried through the colon to the ileum and pierces the ileum about an inch from its end. The needle pierces the ileum from without inward and returns in a reversed direction through the ileum and the colon. The thread is tied on the mucosa of the colon, making a mattress stitch. The short end of the thread is clamped with a hemostat (Fig. 548), and the suture is continued by carrying it back and forth after the manner of a continuous mattress stitch, taking more of the colon than of the ileum in each bite and keeping an inch behind the end of the

Fig. 548.—The author's method of resection of cecum and ascending colon. The bowel ends have been cleaned and the suturing begins from the mucosa of the colon. The needle pierces the colon near its margin from within out, and then takes a bite in the ileum about an inch from its end, penetrating to the lumen of the ileum. It then returns in a reversed direction to the lumen of the colon and is tied, making a mattress stitch. The short end is clamped. The next stitch is taken in the ileum on the left side as close to its mesentery as possible. The needle is then carried through the colon and the next stitch in the ileum is taken close to the right side of the mesentery of the ileum. In this way the mesentery is brought into the colon without too much compression and at the same time is made snug.

ileum. The suture is so inserted that at the mesenteric junction of the ileum the suture is close to the mesentery, then goes to the colon and, returning, takes another bite close to the other side of the mesentery of the ileum. This is drawn snugly. Inserting the suture in this manner avoids cutting off the nutrition that may be carried to the stump of the ileum and at the same time makes apposition sufficiently close to prevent leakage. After the mesenteric border has been well passed the stitch is brought on to the surface by thrusting the needle through the colon from within its lumen and continuing the stitch as a right-angle suture, penetrating all coats. It unites the edge of the colon to the ileum about an inch from its end, while taking a little more of the colon than the ileum in each stitch. A back stitch is made about every third or fourth bite of the

needle (Fig. 549). When the suture has reached its point of beginning it is carried on the ileum one stitch beyond the short end of the thread that was left clamped and is tied to the short end. The knot is tied snugly three times in the line of the incision and is cut short.

In this operation there is not the danger of turning in too much diaphragm, which is an error to be avoided in resection of the small intestine, and it is best to place a row of interrupted mattress stitches of fine tanned catgut around the whole line of sutures. This promotes valve formation and adds to the safety of the line of sutures which has an unusual amount of strain due to the back pressure from the large bowel.

An enterostomy is always done before the clamps are removed. This should be performed in the manner already described, utilizing the principle

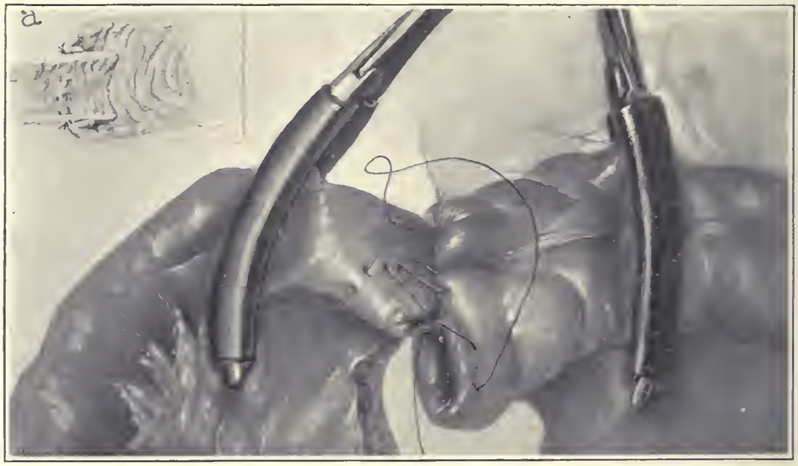

Fig. 549.—The suturing is continued as a right angle continuous stitch, penetrating all coats of the intestine and uniting the edge of the colon to the ileum about an inch from its end. More of the colon than of the ileum is taken in each bite and at about every third or fourth stitch a back stitch is taken. The suture is completed by tying it to the original short end that was left clamped. Insert *A* shows a longitudinal section of the bowel after completion of the first row of sutures and the insertion of the catgut mattress sutures.

of Coffey but instead of placing the enterostomy in the colon, as I originally advocated, it is made in the ileum about one or two inches above the line of suturing. A medium or small sized soft rubber catheter with several perforations near its end is used and should be brought through a stab wound in the abdominal wall to the outer side of the incision and the distal end clamped before the catheter is placed in the enterostomy wound (Fig. 550). The end of the catheter should go through the lumen of the sutured bowel and about an inch of it should rest within the colon. The catheter should not be large, for it may cause obstruction, and a small catheter will give sufficient exit to gas and liquid feces, which is all that is necessary. The omentum in the neighborhood is brought over the enterostomy and the line of union of the bowel, and fastened in position with a few interrupted sutures of fine

tanned catgut. The wound in the mesentery is closed by a continuous suture of catgut and the intestinal clamps are removed.

Abdominal wounds after resection of the bowel, and particularly the large bowel, are best closed with interrupted sutures of silkworm-gut in order to avoid the unfortunate consequences that might follow infection of the wound if catgut sutures were used.

The advantages of enterostomy after resection of the cecum are obvious. One of the great difficulties after this operation is the accumulation of gas. Some surgeons make a permanent enterostomy to avoid this. Others make an end-to-side union and bring the stump of the colon to the abdominal wall. The great advantage of lessening the pressure of gas on the suture line during the healing process has already been discussed. This is obtained by an enterostomy, such as has been described, and the convalescence proceeds without distention and with but little discomfort. The catheter is removed

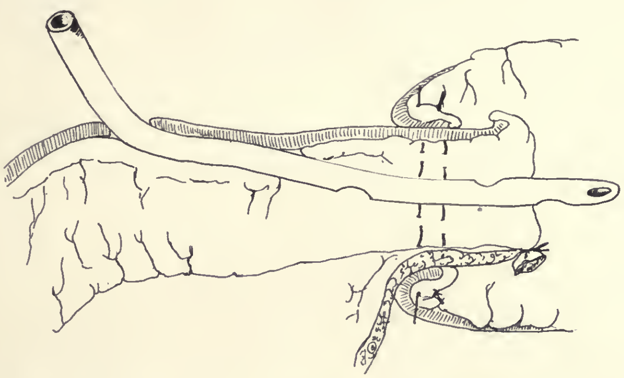

Fig. 550.—Longitudinal section of the completed operation with the enterostomy tube inserted through the ileum. The enterostomy is done by the technic previously described. The tube should be a medium sized or small catheter.

in a week or ten days and its removal is usually followed by no leakage of fecal matter, merely a drainage of purulent serum until the tract closes.

The efficacy of the valve formation is shown in the accompanying roentgenogram, which was taken after an enema of about three quarts of barium suspension had been introduced into the rectum. The picture (Fig. 551) was made forty-one days after resection of the cecum and ascending colon. Although this pressure is estimated to be greater than the normal pressure in the colon none of the barium reached the ileum. There has been no symptom of obstruction, showing that the union at the site of resection is sufficiently patent. This method of operating or the principles underlying the method, such as the treatment of the mesentery and of the ends of the bowel, and end-to-end union, I have employed in ten consecutive cases of resection of the cecum and ascending colon without a death and without any complication following the operation.

Resection of any other portion of the colon down to the lower sigmoid can be done by the method described for resection of the small bowel except

that as a matter of precaution, an additional layer of sutures, preferably interrupted mattress sutures of fine tanned or chromic catgut, is placed around the bowel close to the original row. Of course, there is no occasion for any valve formation in such a resection, and as small a diaphragm as possible should be turned in. As the fecal matter in the large bowel is more nearly solid than in the small bowel and as the surfaces of the colon are more irregular, it is well to place this additional row of sutures, which seems unnecessary after resection of the small bowel.

There is a marked tendency for gas formation in the colon and if the re-

Fig. 551.—A roentgenogram of the valve made after resection of the cecum and ascending colon by the method just described. The roentgenogram was taken forty-one days after the operation. The arrow shows the stump of the colon. Though the valve was subjected to the pressure of three quarts of barium enema, it seems entirely competent.

section is on the left side, or on the left of the midline, a rectal tube or a stomach tube should be passed from the anus well through the site of resection and kept in position for four or five days. This may be done by fastening the tube at the anus either by a suture to the skin, or by passing a safety pin through the tube and letting the tube at this point emerge through a perforation in a broad strip of adhesive placed from one buttock to another. If the tube is not stiff it may double up in the rectum and it should always be passed through the point of resection under the guidance of the hand immediately after the intestinal clamps have been removed. If

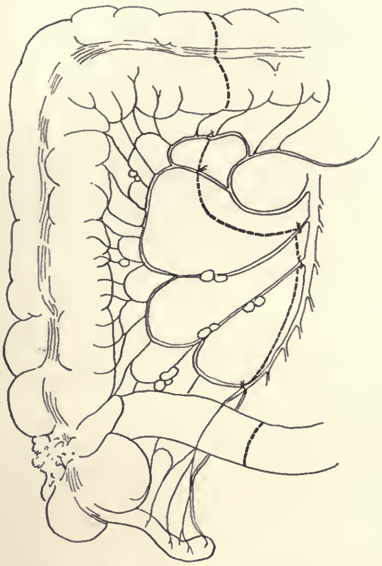
Fig. 552.—Lines of incision for excision of the bowel and mesentery in cancer of the cecum or ascending colon.

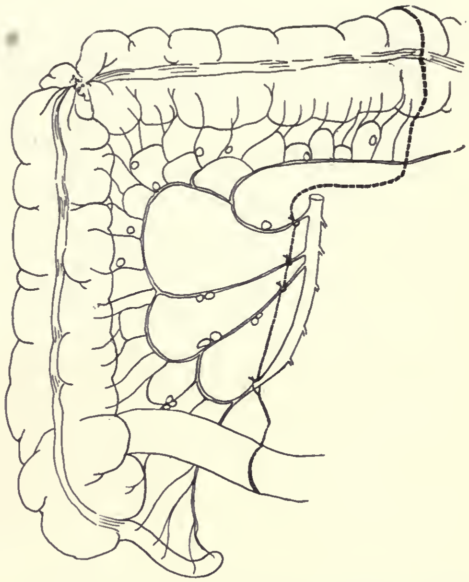
Fig. 553.—Lines of incision for excision of the bowel and mesentery in cancer of the hepatic flexure of the colon.

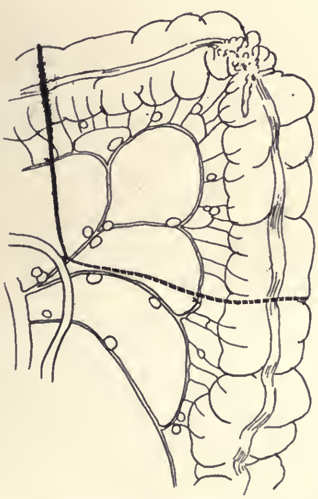
Fig. 554.—Lines of incision for excision of the bowel and mesentery in cancer of the splenic flexure of the colon.

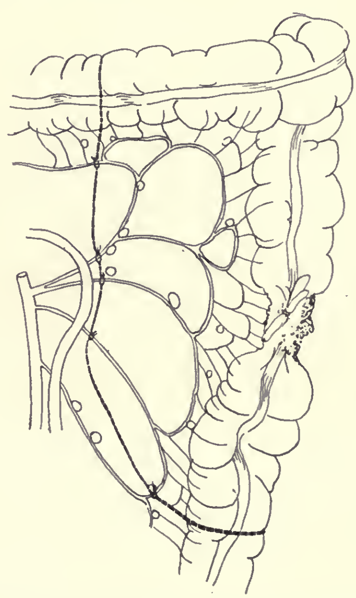
Fig. 555.—Lines of incision for excision of the bowel and mesentery in cancer of the descending colon.

there seems to be doubt about the tube remaining in position its tip may be fixed to the intestinal wall about three inches to the oral side of the resection by transfixing the intestinal wall and the tube with a catgut suture. This is done by pressing the tip of the tube firmly against the wall and passing

the suture through and tying it in several knots. The suture is of fine tanned or chromic catgut and the knot of the suture is buried with a purse-string suture of silk or linen which may be further reinforced by bringing the omentum over to this region. Such a procedure will take only a few minutes and if the surrounding structures are well protected with moist gauze and the catgut suture is regarded as a septic suture and immediately buried, there should be little danger of infection. Peristalsis when reestablished will in its efforts to extrude the tube readily loosen the suture. In the right side of the transverse colon an enterostomy should be done according to the method indicated.

Wherever the site of operation on the colon, great stress should be placed upon the first step of thoroughly mobilizing the colon by dividing the at-

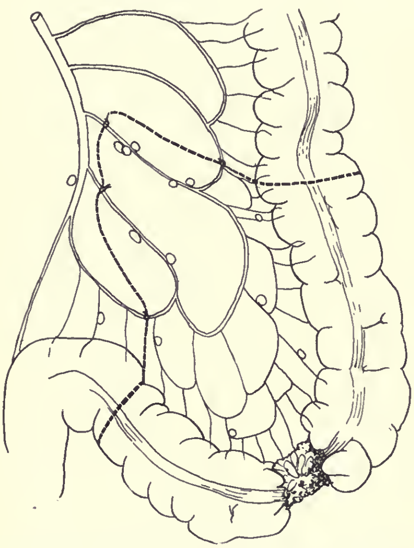

Fig. 556.—Lines of incision for excision of the bowel and mesentery in cancer of the sigmoid.

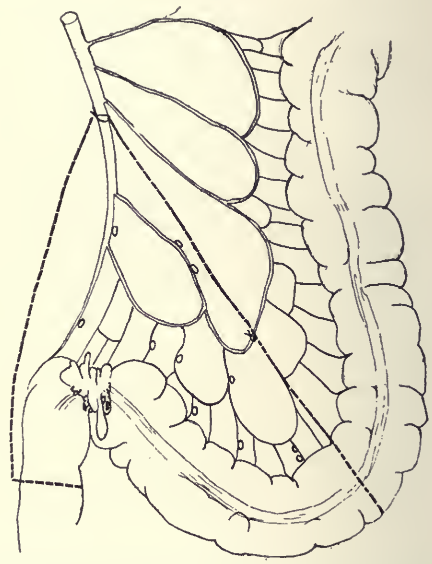

Fig. 557.—Lines of incision for excision of the bowel and mesentery in cancer of the terminal sigmoid.

tachments of the peritoneum on its outer side to the abdominal wall. In this manner the descending colon which is difficult of access can, as a rule, be readily brought into the wound. It must also be borne in mind that in operations for malignant tumors a considerable portion of the apparently healthy bowel and mesentery must be excised. The illustrations show approximately the amount of bowel and mesentery that should be removed in cancer of the colon (Figs. 552, 553, 554, 555, 556 and 557).

Cancer in the terminal portions of the sigmoid is so near the rectum that a part of the rectum must be removed along with the sigmoid. The operation here involves somewhat different principles from those in which a resection is done entirely within the peritoneal cavity and will be taken up along with surgery of the rectum.

Obstruction of the bowel due to cancer of the colon must be managed somewhat differently from obstruction due to bands or strangulated hernia. In damaged bowel, such as a strangulated hernia or intussusception, there is great danger of absorption of toxic products from the affected loop. These products may arise within the mucosa and result from a perversion of the normal function of the glands of the mucosa, or they may to some extent be formed within the lumen of the bowel and can more readily gain access to the portal circulation through the damaged bowel than through normal intestine. Under either condition the necessity of immediately resecting the damaged loop which is the source of toxic material is obvious. This may frequently be accompanied by an enterostomy. Obstruction due to cancer of the colon, however, is mechanical and death results from the damming back of the fecal current. Such an obstruction is not nearly so quickly fatal as is an obstruction higher up in the intestinal tract or when a loop of bowel has been damaged by strangulation, volvulus or intussusception, because the damaged loop generates toxic material more injurious than that which results solely from a mechanical damming back of the fecal current. The principles, then, of treating obstruction due to cancer of the colon are; first of all, giving exit to the dammed back bowel contents. This is the main indication and as there is no unusual amount of toxic material being generated by the cancer the operation for removal of the cancer should never be done at the time the obstruction is relieved by an enterostomy. The method of procedure in such instances is first to wash out the stomach, which should be the first step in the treatment of every intestinal obstruction. The stomach should be thoroughly cleaned by a lavage of soda water until the water returns clear. If the point of obstruction can be determined before the operation so much the better, but if it is not definitely determined it would be wise to make an incision over the right iliac fossa and do an enterostomy on the cecum if it is apparent that the obstruction is distal to the cecum. The suturing in of a large rubber catheter, utilizing the principle of Coffey as has already been discussed, will be sufficient to relieve the obstruction and draw off the liquid feces. Fecal matter in the cecum is normally liquid. This operation can usually be done under a local anesthetic, which adds considerably to the margin of safety in operating on these patients. From one to two weeks later, depending upon the condition of the patient, the exact location of the growth is determined by a barium enema injected from below, together with a suspension of barium injected through the enterostomy tube. Two days after this has been done a radical operation for resection of the growth may be performed. The technic for this has been described. If the cancer is so located that it is not necessary to excise the cecum, the enterostomy tube is left in place for a week after the second operation and is then withdrawn. This procedure may be carried out when there is only partial obstruction, though if a cancer of the colon can be diagnosed when there is no obstruction, it may be excised at one operation.

Formerly excision of cancer of the colon at one sitting was considered a

very dangerous operation and the mortality was reduced considerably by adopting the procedure of Mikulicz. Here, in the first stage, the loop of bowel containing the growth is mobilized and brought into the wound. Its limbs are sutured to each other. If there is an obstruction an enterostomy may be done on the cecum or a small tube is inserted in the loop to relieve the gas and liquid feces. Whether there is obstruction or not, the loop is packed around with gauze until the peritoneal cavity has become well walled off and after a week is excised, preferably with the cautery. This results in an artificial anus. A few weeks later the two segments of colon that were in contact and were sutured together when the mobilized loop containing the cancer was first delivered into the wound are opened into each other by inserting the blade of a pair of forceps in one of the open bowel ends and the second blade in the other end, and then clamping the forceps so as to produce necrosis. Later still, the external opening is closed. Though this method resulted in the reduction of operative mortality, it necessitated a rather limited resection of the bowel and required three or four different operations. During intervals between these operations the wound is flooded with the fecal contents.

Bevan[5] has called attention to the disadvantages of the Mikulicz method and practices a right iliac enterostomy with later a resection of the loop containing the cancer, and still later closure of the enterostomy opening. This leaves a clean field for the resection.

If, however, an enterostomy is done by the method that has been described and through a muscle-splitting incision it will require no operation for its closure, the mere withdrawal of the tube being sufficient. The end-to-end union will permit a resection of a larger amount of bowel than is possible with a lateral anastomosis, and if carried out according to the technic described has other advantages, which have been mentioned.

In operations upon the rectum and terminal sigmoid where the fecal matter is largely solid an enterostomy by insertion of a large rubber catheter in the cecum is not satisfactory. Mixter's operation (pp. 600-602) is best here and should always be used in inoperable cancer of the lower sigmoid and rectum. A permanent anus may be established or, if it is thought wise later on to restore the continuity of the intestinal tract, this can be done by anastomosing the severed ends of the sigmoid. A restoration of the fecal current to normal should not be attempted for a number of weeks, and preferably several months, after the resection of the rectum or lower sigmoid. Often when the patient has learned to care for the colostomy opening he is much more comfortable with a permanent colostomy than he would be if the fecal current were restored after the sphincteric apparatus of the lower rectum and anus has been destroyed.

A diverticulum, called Meckel's diverticulum, is sometimes found. It is an embryologic remnant left in the ileum about one or two feet from the ileoce-

[5]Surgical Clinics of Chicago, February, 1920, Philadelphia, W. B. Saunders Co., p. 9, et seq.

cal valve. This is a congenital deformity but may be the source of obstruction or of adhesions and pain (Fig. 558). It can be removed by first clamping the loop of bowel from which the diverticulum arises, after stripping it of fecal matter, and then surrounding the loop with moist gauze. The further method of dealing with it depends upon its size and the width of its base. Frequently an intestinal clamp can be adjusted at the base of the diverticulum which is then severed close to the clamp, leaving a sufficient margin of tissue for suturing so the lumen of the bowel will not be narrowed at this point. If, as often happens, a mesentery runs along the diverticulum, it is separated and ligated with catgut. It is then divided and the diverticulum is clamped close to the intestine and cut away. The small margin of intestine included in the rubber covered intestinal clamp placed near the base of the

Fig. 558.—Meckel's diverticulum in the lower ileum.

diverticulum is carefully cleaned by sponges wrung out of bichloride solution and the edges of the wound are approximated with a fine tanned or chromic catgut lock stitch. This is done not only to approximate the margins of the intestinal wound but to control bleeding. The clamp is then removed and this line of sutures is buried by a continuous right-angle stitch of linen in a straight needle, taking only a sufficient amount of bowel wall to bury the first line of sutures.

Occasionally it is necessary to do a lateral anastomosis in order to overcome an obstruction in the bowel which it is not practical to remove. This may be permanent, as in inoperable cancer of the splenic colon when a lateral anastomosis may be made between the transverse colon and the sigmoid. It may, however, be utilized as would the enterostomy operation in order to overcome obstruction and later to permit a radical operation upon the cancer or stricture which causes the obstruction. Some-

times, too, an anastomosis between the cecum and the sigmoid is indicated. This, of course, involves the same principle as lateral anastomosis and when there is obstruction along the colon and other portions of the intestine cannot be readily approximated without tension, a cecosigmoidostomy will offer excellent prospects of relief. When performed for stasis, however, though superior to ileosigmoidostomy it is still very unsatisfactory so far as clinical cure or improvement of the patient is concerned.

A lateral anastomosis is performed in much the same way as a gastroenterostomy. The intestinal loops to be anastomosed are selected so they can be easily approximated and overlapped without the slightest tension. Tension in any operation of this type is fatal to success, for the sutures are certain to cut loose under tension and in cancer, where the vitality of the patient

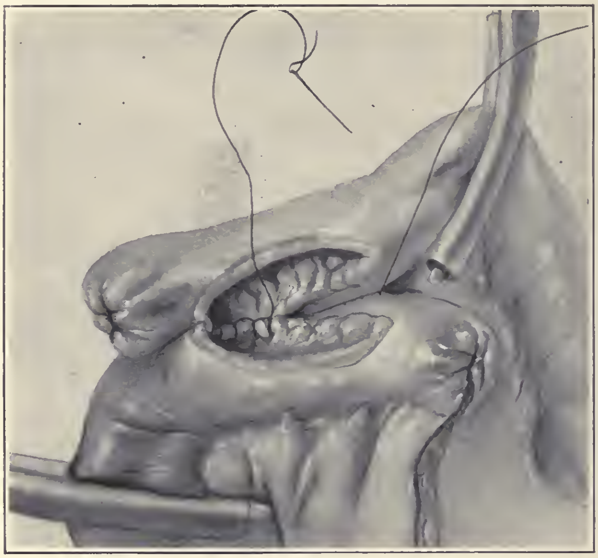

Fig. 559.—Lateral anastomosis of the intestines. The ends of the bowel are closed with pursestring sutures and the openings are made close to the invaginated ends. The suturing is done as in gastroenterostomy.

and the healing of tissues is at a low ebb, everything possible must be done to promote healing of the intestinal wound. If the anastomosis is between loops of small intestine it should be done along the convex border opposite the mesenteric attachment. If the lateral anastomosis is to be between loops of the large intestine it is preferably done through the anterior band, splitting the band in the center, as this makes a smoother surface though it may tend later to cause a contraction of the anastomotic opening. After selecting the two loops of bowel and arranging for thorough mobilization by incising the peritoneum on the outer side of the mesocolon if necessary, a row of fine linen or silk sutures is placed just on the margin of the band, if the colon is being united, in the same manner as the jejunum is united to the stomach in gastroenterostomy. These sutures are placed with a curved needle

and are right-angle continuous sutures, taking a back stitch about every fourth insertion of the needle. After this row has been placed, another back stitch is taken and the needle and thread are wrapped in gauze. The bowel is

Fig. 560.—Lateral anastomosis between the jejunum and dilated duodenum for obstruction at the terminal duodenum.

incised about the middle of the band, the edges of the wound are caught with mosquito forceps, and the mucosa is cleaned with moist gauze wrung out of bichloride solution. The other loop is incised and cleaned in a similar

way. The edges of the wound are united by a No. 1 tanned or chromic catgut suture in a round curved needle, beginning at the end of the incision where the first row of sutures terminated (Fig. 559). After tying, the short end is clamped with a hemostat and the suture is carried on as a continuous lock stitch, snugly applied to control bleeding. When the other end of the wound is reached the needle is thrust through from the mucosa to the peritoneal surface and the suture is completed as a right-angle continuous suture, penetrating all coats and taking the stitches close enough together to control bleeding. It is best to take a back stitch about every fourth insertion of the needle. Just before the line of sutures is concluded the pressure of the intestinal clamps is slightly relaxed by gently unlocking the handles just enough to permit a return of the circulation and to demonstrate whether there are bleeding points. This should be done very carefully first on one side and then on the other, because if the clamps are loosened too much the wound may be flooded with fecal matter. There is not so much danger of hemorrhage here as in gastroenterostomy. After demonstrating whether there are bleeding points the pressure of the clamps is reapplied and the suture is concluded and tied three or four times to the original end that was left clamped with the hemostat. The needle and thread with which the first posterior row of sutures was applied is taken up and continued along the anterior surface of the wound, burying the catgut row and placing the sutures as a right-angle continuous stitch, which terminates at the point of its beginning and is tied to the original end. This knot is buried by an interrupted mattress suture and another is placed near the other angle of the wound in order to take the strain from the line of sutures (Fig. 560). The greatest tension naturally will be at the two ends, just as one rips cloth by pulling it apart first at the edge, not beginning at the center; so these two extremities of a line of sutures should always be protected. After cleaning the sutures with moist gauze, the bowel is returned and the abdomen is closed without drainage.

Practically the same technic, as has been described, is used in cecosigmoidostomy, except that the union cannot always be made between the bands of the cecum and the sigmoid, but preferably between parts on which there is least tension. Some operators advocate bringing the mesosigmoid to the mesentery of the cecum in order to prevent obstruction. This does not seem necessary because if an effort is made to join these two mesenteries there is much more likelihood of an obstruction from the slipping of a loop of small intestine through a small opening between them that may not be completely closed than there would be if no effort was made to approximate them. The cecum should never be anastomosed to the sigmoid unless both of these portions of the bowel are so mobilized that there will be not the slightest tension on the line of sutures.

CHAPTER XXVII

OPERATIONS ON THE APPENDIX, PERICOLONIC BANDS, THE LOWER SIGMOID, THE RECTUM, AND THE ANUS

APPENDICITIS

There are almost as many methods of performing appendectomy as there are technics for the correction of retroversion of the uterus. As usual, however, the simplest method that is efficient should be one to be adopted. The McBurney incision is very satisfactory, especially in acute appendicitis. As this incision is often used it is illustrated in some detail (Figs. 561, 562, 563, 564, 565, 566, 567 and 568). In my experience I have tried the different methods of treating the stump of the appendix, but for the last twelve years I have practiced two procedures that have given the utmost satisfaction. In the majority of cases the appendiceal stump is treated simply without being buried, according to the general technic employed by the early operators for appendicitis. If this is impossible because of the diseased condition of its base, the appendix is excised flush with the cecum and the cecal wound treated as though it were a stab wound, using either a single pursestring suture after controlling the bleeding, or else suturing the margins of the wound with a continuous suture of tanned or chromic catgut and burying this with a second row of right angle sutures of linen or silk. In suturing wounds of the intestine, if the bleeding is readily controlled, one row of sutures is all that is necessary. If, however, there is doubt about controlling the bleeding, as where the bowel is clamped in such a manner as to cut off the circulation, or in the larger bowel, where the surface is irregular and the intraintestinal pressure is considerable, two rows of sutures should be employed. As wounds of the cecum belong to this latter class two rows of sutures after complete excision of the appendix are advisable. Such indications, however, do not often arise, for usually a sufficient amount of the appendix can be left to heal as a stump. The technic for appendectomy that I have found satisfactory for either chronic appendicitis or the great majority of cases of acute appendicitis is as follows:

The appendix is, if possible, delivered into the wound. It is clamped about a third of an inch from its base and two catgut ligatures of No. 1 tanned or chromic catgut are carried through the mesoappendix close to the base of the appendix. The base is tied flush with the cecum with one of the ligatures, tying three knots and clamping the long ends. The mesentery of the appendix is tied with the other ligature (Fig. 569). If the mesentery is fat the proposed site of ligation is first clamped with a pedicle forceps. In fat patients the mesoappendix sometimes tears and retracts when

elamped. The elamping should not be too near the root of the mesentery so the fat retracted mesoappendix can be readily caught if sueh an aeeident occurs. When there is but little fat there is no oeeasion for elamping. After tying the mesoappendix it is severed with seissors, leaving a suffieient margin

Fig. 561.—The skin incision for the McBurney muscle splitting operation.

Fig. 562.—The aponeurosis of the external oblique is split in the direction of its fibers.

beyond the ligature to prevent it from slipping. The ends of this ligature are tied snugly around the base of the appendix over the first ligature and are cut short. This prevents retraction of the stump of the mesoappendix which sometimes oeeurs and which may result in the tearing of small veins with disagreeable oozing. The base of the appendix is surrounded with moist gauze and is

severed with an electric or thermo cautery close to the clamp and about a fourth of an inch beyond the ligature (Fig. 570). A dry sponge is placed by the stump of the appendix and the eschar left by the cautery together with most

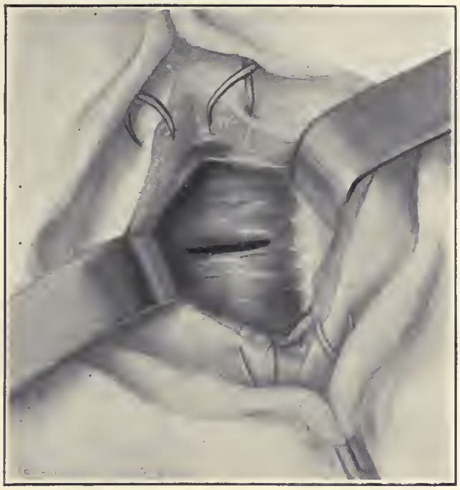

Fig. 563.—The aponeurosis of the external oblique has been split and drawn apart with retractors. The fibers of the internal oblique and transversalis, which are nearly parallel in this location, are separated by inserting closed scissors and opening their blades.

Fig. 564.—The fibers of the internal oblique and transversalis are held apart with retractors. The peritoneum is shown in the wound.

of the mucosa of the stump is curetted away on to the gauze sponge with a small sharp curet (Fig. 571). The point of a scalpel will also serve for this.

A drop of pure carbolic on the end of a probe is rubbed into the stump of the appendix and the gauze sponge on to which the eschar and mucosa were curetted is removed. The excess of carbolic is removed with a dry gauze

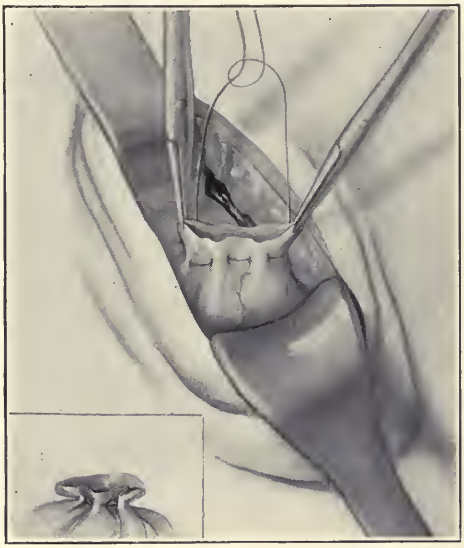

Fig. 565.—The peritoneum is closed with pursestring suture or a continuous mattress suture which everts the edges of the cut peritoneum and brings broad peritoneal surfaces in contact. The insert shows the suture in the peritoneum after it has been tied.

Fig. 566.—The fibers of the internal oblique and transversalis muscles are approximated by a suture of plain catgut which is loosely tied.

sponge and the ends of the ligature are cut about a fourth of an inch from the knot. The wound is made and closed as described in the chapter on abdominal incisions and as shown in Figs. 561 and 568.

Where the appendix cannot be delivered into the wound the technic is altered to suit the occasion. The appendix is first ligated, clamped and sev-

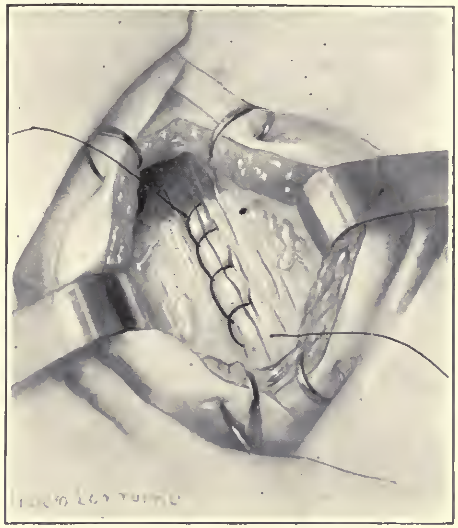

Fig. 567.—The aponeurosis of the external oblique is brought together with a continuous lock stitch of plain catgut.

Fig. 568.—The skin is closed with a subcuticular suture of fine tanned catgut.

ered at its base, treating the stump as has been described and also disinfecting the end that is clamped in the forceps. The mesoappendix is then clamped from the base outward by a series of forceps and is severed as each

forceps is applied. The vessels in the mesentery are controlled by sutures of catgut. In some difficult cases the technic originally suggested by S. J. Mixter is valuable. Here the appendix is severed and if it is difficult to clamp

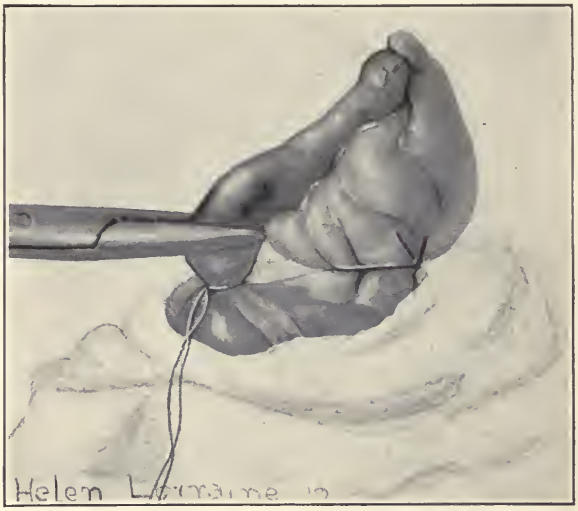

Fig. 569.—The appendix and its mesentery are tied with tanned catgut.

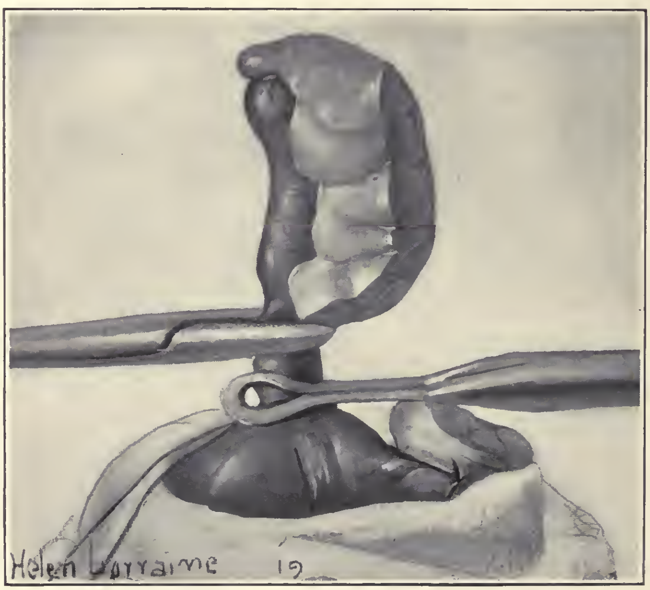

Fig. 570.—The appendix is severed with an electric cautery.

the mesoappendix on account of extensive adhesions and if the appendix is not too acutely inflamed, an incision is made around it close to the clamp, going only through the peritoneal and muscular coats and down to, but not through, the mucosa. This incision is very important and must

be carefully made. The mucosa should be stripped out by gently pushing down the cuff of the peritoneal and muscular coats and grasping the mucosa with forceps as it is being delivered from its attachment to the muscular coat. The stripping is done with dry gauze on sponge holders or pedicle forceps but must be done carefully, for if the mucosa tears the wound may be infected and the distal part of the appendix is then delivered with considerable difficulty. For this reason if there is much inflammation and the coats of the appendix have become infiltrated and weakened, the mucosa is likely to tear and this procedure should not be attempted. After the mucosa of the appendix has been delivered in this manner, the mouth of the shell from which it was extracted, which consists of the muscular and peritoneal coats, is clamped and tied to prevent bleeding. This shell fills with a blood clot and presents an exact cast of the appendix. If the mucosa has not been injured the blood

Fig. 571.—The eschar and the mucosa in the stump are curetted.

clot is readily absorbed. A complete peritoneal covering is left where otherwise would be an extensive raw surface which would result from the complete delivery of an appendix in such a difficult position. This procedure is particularly valuable when a long adherent appendix points toward the liver.

The difference in results of an operation in which the stump of the appendix has been treated as described and in which it has been buried is well shown by the accompanying cuts (Figs. 572, 573, 574 and 575). A false analogy is often responsible for burying the stump of the appendix. It has been assumed that there should be no raw surface left in the peritoneal cavity whenever it can be prevented. This, as a rule, is a good doctrine, but there are exceptions. Because the stump of a broad ligament or of an amputated uterus is buried it has been supposed that the stump of the appendix should be likewise treated. After salpingectomy or a hysterectomy the ligated pedicle or sutured surface is turned into well vascularized

tissue and can easily be absorbed or vascularized. The stump of a ligated appendix, however, is buried, not into solid well vascularized tissue, but into the cavity of the cecum (Fig. 573). The nutrition to injured tissue de-

Fig. 572.—The stump of the appendix is tied and a pursestring suture for invagination of the stump is placed.

Fig. 573.—A sectional view shows the result of the invaginating method. The blood supply is partly cut off by the pursestring suture, a piece of necrotic stump is left in the closed cavity, and the mass of invaginated tissue can be almost surrounded by fecal contents. It is impossible for the omentum or mesentery to reach the stump of the appendix and a prominent lump is left in the wall of the cecum which may be a future source of ulcer or of cancer.

pends, among other things, partly upon the amount of damage to be repaired and partly upon the ease with which the blood circulation can approach the site of injury. In the simple treatment of the stump, the repair of

the base of the appendix flush with the eolon is unobstrueted. Not even a elamp that crushes the mueosa has been plaeed here and so the blood supply eomes to the ligated base without hindrance. The stump of the appendix whieh

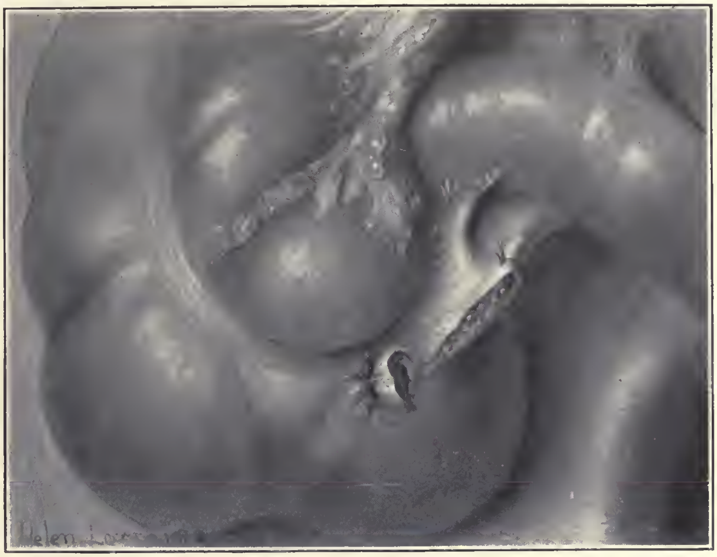

Fig. 574.—The simple method of treating the stump of the appendix. The appendix has been ligated and the stump disinfected.

Fig. 575.—A sectional view showing the simple method of treating the stump of the appendix. The interior of the cecum is undisturbed and is left perfectly smooth.

is ligated is, of course, necrotic material. It has probably been rendered asceptie by severing it with a eautery, euretting and disinfeeting with carbolic. This ncerotic material to be successfully disposed of must be removed by phagoeytes.

In the simple treatment of the stump these phagocytes can approach, not only through the unobstructed lymph and blood circulation of the cecum to the base of the appendix, but can also reach the stump by the

Fig 576.—Reproduction of illustration by Bunts, showing diverticulum following burying the stump of the appendix.

Fig. 577.—Drawing of a diverticulum that we have seen following burying the stump of the appendix.

omentum, which may plaster over the stump, or through the mesentery of adjoining loops of bowel. In this way even an infection of the stump may be overcome by the vigorous and obstructed attack of the leucocytes (Figs. 574 and 575). After the stump is digested and removed the adherent omentum or mesentery drops away and leaves a smooth cecal wall which presents

merely a slight scarring. I have had occasion to operate for other causes, on a number of patients in whom the stump of the appendix has been treated in this simple manner and in no instance have I found a serious adhesion or other complication. In the majority of cases in which the stump has been buried I have found either unusual adhesions or a lump in the bowel or else a diverticulum, such as has been described by Bunts and which he has well illustrated.

If we were to establish ideal conditions for the formation of an abscess we would probably prescribe; first, the diminution of the blood supply to the tissues in which the abscess is to be located; second, the presence of ne-

Fig. 578.—A small rounded residue often seen at the site of the appendix stump following appendectomy; also sometimes seen about the base of a diseased appendix before removal. "In some cases showing such a residue after barium meal, the operation had been performed years before." The illustration was kindly sent me by Dr. James T. Case. He says that he believes that this residue has some relation to the pursestring suture by which the stump is buried. Jour. Am. Med. Assn., Nov. 6, 1915, lxv, pp. 1628-1634.

crotic material; and third, the formation of a closed sac. These conditions are filled when the stump of the appendix is buried, for the pursestring suture not only forms a closed sac in which the necrotic stump is enclosed but it cuts off some of the blood supply that must reach the base of the stump to produce repair, and thereby calls for a much greater hyperemia of the cecum than would otherwise be necessary. This excessive hyperemia often means lymphatic deposits and permanent adhesions, whereas if the stump is treated simply no extra burden is placed upon the tissues and there does not exist the necessity for additional hyperemia. Then, too, the neighboring mesentery

and omentum aid in taking care of the necrotic stump when it is not buried. In addition to forming a cavity that contains necrotic material and cutting off the nutrition to this cavity the wall of the cecum within the grasp of the pursestring suture is inverted into the lumen of the cecum, which is one of the most septic portions of the intestinal tract. This inversion produces also a beginning intussusception and a protuberance on the mucosa of the cecum which may possibly be a starting point for ulceration or for cancer.

The diverticulum that occasionally forms after burying the stump is thought by Bunts[1] to be due to destruction of the circular fibers around the base of the appendix by the pursestring suture (Figs. 576 and 577). Case[2] has also shown by roentgenograms that there may be a stasis at the base of the appendix where a pursestring suture has been used even years after the operation has been performed (Fig. 578).

The two chief objections to the simple method of treating the stump of the appendix are; first, that it does not "look good"; and, second, that the ligature on the stump of the appendix may blow off. The answer to the first of these objections is obvious. Surgical operations should be finished in a neat and workman-like manner if possible, but more important still, they should be based upon the anatomy, physiology, and pathology of the tissues involved. It would probably look well, for instance, to close a hernial wound by a careful subcuticular suture in the skin without the proper approximation of the deep structures, but no one would consider this good surgery. As to the ligature blowing off, this is much less likely to happen on the stump of an appendix than on a blood vessel. The stump of the appendix is soft and succulent tissue and the ligature sinks in well. The intracecal pressure never even approximates the blood pressure, so if any surgeon is capable of ligating a large blood vessel, he should surely be able successfully to tie the stump of the appendix. If, for instance, in an amputation of the thigh he applied a ligature to the femoral artery and this ligature slipped and the patient bled to death, the surgeon would not be justified in condemning the general method of placing ligatures on blood vessels, but he should assume that the ligature was not properly tied. If a ligature "blows off" the stump of an appendix it is more the fault of a carelessly applied ligature than a reflection upon the technic of the operation that the surgeon attempted to follow.

Naturally, this method of treating the stump of the appendix does not necessarily apply to larger wounds of the intestine, and particularly to the treatment of the ends of the intestine when lateral anastomosis is done. Where the wound is large, and bears the brunt of the current of peristalsis, peritoneal surfaces must be approximated and ligation is not applicable, but in the appendix where the aperture is small and does not receive the impact of the current of intestinal contents the simple method that has been described seems excellent.

When an abscess results from appendicitis or when peritonitis has de-

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[1]Surg. Gyn. & Obst. Dec. 1914, p. 791.
[2]Jour. Am. Med. Assn., Nov. 6, 1915, lxv, 1628-34.

veloped, drainage is necessary. A small amount of murky, thin fluid when the appendix has not ruptured does not call for drainage, but in the presence of a distinct abscess or where the appendix has ruptured, particularly if the clinical symptoms show marked reaction, drainage should be employed. For acute appendicitis, particularly if there is to be drainage, I always use the McBurney muscle splitting incision. When there is a history of recurrent appendicitis, or of a so-called chronic appendicitis, which may be accompanied by other lesions, a long incision near the median line is made unless the diagnosis can be quite clearly limited to the region of the appendix and the terminal ileum. Chronic cases, as a rule, demand more thorough exploration than can be done through a muscle splitting incision, but in acute appendicitis the McBurney incision offers ample space for removal of the appendix and makes hernia after drainage much less likely to occur than if a long rectus incision was made. It is unusual to find a hernia in drainage cases of appendicitis when the McBurney incision is employed, and even if it occurs it usually gives but little discomfort and can be readily repaired; whereas with a rectus or median incision, especially if there is drainage, hernia is not uncommon.

After making the McBurney incision and opening the peritoneum the presence or absence of free fluid is noted. The finger is inserted and the appendix is located by palpation. If there are no adhesions the cecum is pulled up into the wound and the appendix is clamped near its base, if it is not gangrenous at this point. If, however, the appendix is adherent, and particularly if it is gangrenous and ruptured, it should be carefully isolated by the finger and brought into the wound with as much gentleness as possible to avoid any further spreading of the infection. Seizing an appendix that is strutted with pus, or that has become gangrenous, with an ordinary pedicle forceps is unwise, as the infiltrated tissue will almost certainly be cut through like cheese and the bleeding will smear the pus over surfaces that otherwise might not be infected. Such an appendix should be caught with light bladed sponge-holding forceps with corrugations on the grasping surface. The forceps are not locked but are closed just sufficiently to hold the appendix while drawing it into the wound. Several sponge-holding forceps are used if the base is the first part of the appendix that is located. The first forceps seize the appendix near the base, pull it up, and another forceps seize it lower down and make further traction while it is being freed from the surrounding tissues with the fingers. In a very fat patient it is often difficult to recognize an infiltrated appendix because a fatty tag or fold that is infiltrated may so simulate it as to be very confusing. If the finger can find the line of cleavage and follow this without too much force the tissues can usually be separated without doing any material damage. When an obstruction is met no effort should be made to punch through it with the finger, but another line of cleavage should be sought. If an abscess is present it is opened with the finger to the outer side of the appendix and cecum if possible. It is best to protect the surrounding structures with a moist gauze pack before opening it. When

the abscess is in the pelvis or when the appendix has already ruptured into the free peritoneal cavity no gauze should be placed in the abdomen. Walling off abscesses with gauze is not so frequently done now as it was a few years ago. If too much gauze is placed in the peritoneal cavity and if it is too roughly placed it may do more harm than good.

While emptying the abscess the patient is turned over on the right side for a few minutes and the finger is held in the abscess cavity to permit the pus to drain out of the wound by gravity. The patient is then turned on his back and the abscess is gently cleaned until it is dry with gauze sponges in sponge-holding forceps. The stump of the appendix is then treated in the same manner as in recurrent or chronic appendicitis. Often it is impossible to tie the stump of the mesentery to the stump of the appendix because of infiltration with inflammatory products, but otherwise the technic is the same. If the appendix has not ruptured but seems to be on the point of rupturing, the utmost care should be exercised to prevent it from bursting during the manipulations to deliver it, and the wound should be carefully protected with gauze.

When there is an abscess or when the appendix has ruptured, drainage should always be instituted. This usually consists of a single rubber tube with only one perforation near its end which is inserted down to the abscess cavity or into the culdesac of the pelvis. If the abscess cavity is rather large, and particularly if there is much bleeding after enucleating the appendix, the raw surface is packed firmly with dry gauze that is left in place about four minutes. This permits the blood to clot and when the packing is removed the bleeding is usually controlled. If it has not entirely stopped there will be only a few bleeding points which may be whipped over with a needle and catgut and gently tied, or which may be controlled by placing a cigarette drain down to the bleeding points. When the abscess is behind the cecum there is a great tendency for the bacteria to be carried to the posterior region of the liver unless the abscess cavity is freely opened and well drained. Here a large cigarette drain of gauze in rubber dam is carried into the abscess cavity and in addition a soft rubber drainage tube with one perforation is placed in the pelvis. The drainage tube has an internal diameter of about a third of an inch. The tube is sufficient to drain off the accumulated material in the peritoneal cavity and to cause a moderate reaction from the lymphatics, whereas the gauze that is carried to the abscess cavity produces a much more profound reaction upon the lymphatics and consequently a more marked reversal of the lymphatic circulation toward the abscess cavity than the rubber tube can effect. In this way the lymphatics, instead of absorbing bacteria from the walls of the abscess and depositing them around the posterior region of the liver, will pour lymph into the region of the gauze drainage in an effort to extrude the gauze. These features of drainage have been dealt with in some detail in the chapter on Surgical Drainage, but their application is particularly important here in order to prevent subdiaphragmatic abscess. I feel that if this precaution is taken in abscesses

located behind the cecum or colon a subdiaphragmatic abscess will probably never occur. Since adopting the measures that have been described I have not had a patient with subdiaphragmatic abscess.

The drainage material is brought out at the outer angle of the wound. The peritoneum and inner portion of the wound may be partially closed. If only a rubber tube is inserted, which is usually all that is necessary, except in retrocecal abscesses, the inner portion of the wound in the peritoneum and transversalis muscle can be closed snugly around the tube with two interrupted sutures of catgut. If there is a retrocecal abscess or if the pus is very abundant a single suture of silkworm-gut is placed to reinforce the inner portion of the wound. This is not tied tightly but barely approximates the tissues. The tube is fixed in the wound by a single silkworm-gut suture in the skin. The rest of the wound is packed lightly with iodoform gauze in order to prevent pocketing of the pus. If there is a quantity of pus and much suturing is done the pus is very likely to pocket and abscesses in the abdominal wall will develop. Later, if necessary, the wound can be drawn together with adhesive plaster. Packing the wound lightly with iodoform gauze often prevents any suppuration in the raw surface even though pus drains over it, because the gauze causes a reversal of the local lymphatic circulation, which may be sufficient to prevent infection.

Patients that require drainage are placed in bed with the head of the bed elevated eighteen inches. The extreme Fowler position is no longer used in these cases, as the elevation of the head of the bed seems sufficient. The patient may also be turned slightly to the right side, especially for the first forty-eight hours. This position, however, if uncomfortable need not be maintained. The stomach is washed out and the patient is given hot water by mouth. A dram of bicarbonate of soda and half an ounce of glucose in eight ounces of a one per cent salt solution are injected slowly into the rectum every four hours. If there is extension peritonitis continuous rectal saline with a smaller amount of glucose and soda may be used. This is given under low pressure, but if very disagreeable to the patient is discontinued and given at intervals of four hours. In very ill cases hypodermoclysis of Locke's solution should be given beneath the axilla. If the Locke's solution is absorbed too slowly or causes much soreness, it may be replaced by sterile distilled water, or the distilled water may be given for twelve hours and then the Locke's solution for twelve hours. The objection to using hypodermoclysis in the presence of pus in the abdomen is that the site of the hypodermoclysis may become infected by the hematogenous transfer of bacteria. The method here described may, of course, be used for the treatment of peritonitis due to other causes than appendicitis.

PERICOLONIC BANDS

Bands, or veils, or kinks about the terminal ileum, cecum, ascending colon, and sigmoid have attracted much attention in recent years. The Lane band, which occurs in the terminal ileum usually about two to three inches from the ileocecal valve, is important. The veils or bands about the cecum

and ascending colon are probably less likely to produce symptoms than the Lane band, because the caliber of the large bowel is much larger than of the ileum and it requires, consequently, greater encroachment on the lumen of the cecum or colon to produce interference with the flow of the fecal current. Undoubtedly, a Lane band, which reduces the caliber of the ileum to a third of its normal, may cause colicky pain and symptoms that are often attributed to appendicitis. It is highly important in every case of recurrent or chronic appendicitis to examine the terminal ileum for at least six inches from the ileocecal valve. It is better to examine it for several feet in chronic cases in order to determine whether the symptoms may be due to a Meckel diverticulum.

Attention has been called to bands and veils about the cecum and ascending colon by Jackson, of Kansas City, whose name has been prominently associated with these lesions in this region, just as Lane's has been associated with them in the terminal portion of the ileum.

J. W. Long, of Greensboro, N. C., was one of the first to call attention to bands or veils of the ascending colon or cecum. His early paper on this subject was read before the American Association of Obstetricians and Gynecologists, September 23, 1896, and appears in the Transactions of that year.

In women, bands or adhesions between the sigmoid and the base of the left broad ligament may occur with almost the same regularity as bands in the terminal ileum, cecum, or ascending colon. Hubert A. Royster,[3] of Raleigh, N. C., has called attention to the bands in this region and has secured excellent results in many cases of left-sided pain by recognizing and dividing these sigmoid bands.

No typical operation can be done for these bands. An exact etiology has not been definitely determined. Many investigators from embryologic studies assert that the bands are a perversion of normal processes. Though due to abnormal embryologic development of the peritoneum it is also true that their effect may be at least accentuated by irritating or inflammatory processes in their neighborhood and thus a vicious circle is established. Undoubtedly bands and adhesions may occur solely as the result of peritonitis but the typical bands that have been mentioned seem to be due to abnormalities of development. Hertzler[4] deals very fully with the anatomy and the embryologic development of peritoneal bands and ligaments and shows how they may occur.

If they are causing no symptoms and there is no degree of obstruction there is no occasion for any treatment. If, however, the bands or adhesions are causing symptoms or are interfering with the function of the intestine they should be divided. The method of division depends, of course, upon the location and the character of the band. The Lane band, which is usually narrow and spreads out in a fan-shaped manner, is isolated as far as possible and carefully divided with blunt-pointed scissors. By dividing a small part of the band at a time and making it tense while pushing back the mesentery,

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[3]Tr. Southern Surg. and Gynec. Assn., 1909, and 1912, p. 97, et seq.
[4]Hertzler: The Peritoneum, St. Louis, C. V. Mosby Co., i, 112, et seq.

injury to the mesenteric vessels is avoided. Occasionally a blunt instrument may be inserted beneath the band but this should not be attempted unless it can be done without force, for otherwise injury may be done to the mesentery itself. After division of the bands recontraction at least to the same extent as existed at first probably does not occur, but in order to obviate the possibility of a recurrence, the raw surface is covered by approximating the mesentery of the ileum in such a manner that it will make a fold of the mesentery and cause the mesentery, where it was uncovered because of severing the Lane band, to grow together. This results in a slight loop of the ileum which is sharp but does not interfere with the function of the ileum. A band to the cecum, the ascending colon, or the sigmoid is divided transversely and the healthy tissues at the transverse ends of the incision are approximated by a few sutures. If it is desirable to prevent even a partial recurrence and if the tissues cannot be satisfactorily approximated a free graft from the omentum may be used as was described in the protection of the injured duodenum.

THE TERMINAL SIGMOID, THE RECTUM, AND ANUS

Diseases of the terminal sigmoid and the rectum may be treated as in the same general anatomical division. The excellent work on the anatomy of the terminal sigmoid by W. J. Mayo[5] shows that in the terminal two inches of the sigmoid there is a distinct change in the anatomic structure which bears considerable resemblance to the rectum just above the anal canal. There is a longitudinal arrangement of the mucous membrane at the end of the sigmoid. At the beginning of the rectum there is a rudimentary sphincter which forms a well marked resisting constriction to the readily dilatable sigmoid from above and to the rectum from below. It is here that cancer is likely to occur.

Operation for cancer in this region always involves removal of at least a portion of the rectum along with the terminal sigmoid. As the first stage of this operation an enterostomy is usually done. This should be a complete sigmoidostomy, preferably Mixter's operation, so as to divert the fecal current entirely, and it should be done at least a week before the radical operation for the removal of the affected bowel. If the cancer is located on the proximal side of the rectosigmoid junction, which occasionally occurs, and is not far advanced it may be removed from within the peritoneal cavity by a thorough mobilization of the lower sigmoid and upper rectum, followed by an end-to-end union of the intestine and later a restoration of the continuity of the fecal current by uniting the bowel at the site of the sigmoidostomy.

When the tumor is in the terminal portion of the sigmoid and the patient is not too fat the tube method of Balfour may often be used with advantage without a previous enterostomy. The sigmoid is well mobilized by incising the mesentery along its outer side and the tumor is delivered into the wound as

[5]Mayo, W. J.: Surg., Gynec., and Obst., 1917, xxv, 616 to 621.

far as possible. The growth is excised after first dividing, clamping, and tying the mesentery. The bowel is divided at least two inches beyond the apparent margins of the growth. According to Handley four inches is better, as the cancer cells may be found in apparently healthy intestinal tissue this distance beyond the obvious limits of the tumor. A rubber tube, with the consistency of an ordinary rectal tube, but with an internal diameter of about one-half inch, is inserted into the proximal end of the sigmoid for three inches and is fixed by a suture to the proximal (oral) end. A pursestring suture is placed around this end of the bowel and tied snugly so as to make the junction between the tube and the bowel water tight. The lower end of the tube is introduced into the distal end of the bowel and protrudes through the anus. It is then pulled on and in this manner the divided bowel is approximated and is united by sutures. These sutures may be of chromic catgut and the first row should co-apt the mucous membrane accurately. Further traction on the tube induces more invagination which may be assisted by steadying the lower segment of the bowel with Allis forceps. Another row of sutures is placed to hold the bowel in this position and under further traction a third row can also be placed if necessary. If the omentum is available it is fastened around the line of suture with a few stitches. Fecal matter will pass through the tube for several days until the danger of distention from gas is over. This method is valuable in certain cases but cannot be readily used when there is an excessive amount of fat as the invagination of the fat may produce obstruction or necrosis.

Cancer of the upper rectum or of the rectosigmoid bowel which cannot be eradicated with the preservation of peritoneal covering on the distal part of the bowel, should be treated by the two stage operation. This method, as described by C. H. Mayo, consists, first, in an exploratory incision near the midline. Through this incision the liver is examined with the hand and search is made for metastases. If there are a few enlarged glands which are not fixed and appear to be soft, the operation is not contraindicated, if the growth itself can be well mobilized and there are no other metastases. After first dividing and tying the mesentery, the sigmoid is clamped and divided with an electric cautery well above the growth. The two stumps are disinfected with the actual cautery and the ends are closed by a continuous mattress suture.[6] The mesentery of the lower end is ligated and separated from the sacrum as far down as possible and the end of the bowel is turned into the culdesac by the side of the growth. The pelvis is closed off by suturing the back of the bladder in the male or the uterus and broad ligament in the female to the posterior parietal peritoneum. In this manner the distal end of the bowel including the cancer is isolated in the pelvis. A two-inch incision is then made to the left of the midline, splitting the fibers of the rectus muscle, and is carried through the peritoneum. The proximal end of the bowel which has been closed by sutures,

[6]Mayo Clinics, 1916, p. 325.

is drawn through this incision and sutured to the peritoneum and transversalis fascia within the abdomen by slightly everting the outer edge of the wound. Sutures are so placed that the closed end of the bowel will project about one and a half inches above the skin. This stump is twisted three quarters of a complete turn, as advised by Lilienthal, and is pushed down and sutured to the anterior sheath of the rectus muscle. In this way spiral valves are created within the lumen of the stump of the sigmoid and this, together with the pressure of the fibers from the rectus muscle, gives satisfactory control over the bowel movement. This makes a permanent artificial

Fig. 579.—The Kraske operation for excision of the rectum. The coccyx and lower portion of sacrum have been removed, exposing the posterior portion of the rectum. (After technic of W. J. and C. H. Mayo.)

anus in the left rectus muscle and if properly attended to is very much less inconvenient than it is usually supposed to be.

Six days later the second stage of the operation is done. This operation is performed according to W. J. Mayo's modification of Kraske's operation. After closing the anus with a suture an incision is made from near the anus to a point about midway between the middle and the base of the sacrum on the left side. The soft parts are dissected free and retracted from the coccyx and the lower half of the sacrum. The soft tissues attached to the sides of

the sacrum and coccyx are separated all the way around these bones. The sacrum is divided transversely with a chisel about the second foramen and the lower part of the sacrum and the entire coccyx are removed. The middle sacral artery may require ligation (Fig. 579).

In mobilizing the sigmoid, particularly in its lower portion, care must always be exercised to avoid injury to the ureters. If one ureter is involved in the growth or if it is injured in such a way that it cannot be transplanted into the bladder, its upper end may be securely tied and the kidney will eventually atrophy and does not, according to W. J. Mayo, give any further trouble. Of course, the other ureter and kidney must be normal and uninjured.

In dissecting out the lower portion of the rectum after the levator ani muscles are well defined, the hand is inserted into the wound and the structures posterior to the rectum are shelled out, keeping close to the upper part of the sacrum and packing the cavity with hot moist gauze in order to prevent bleeding. It is important to take the fat surrounding the rectum. The dissection is carried laterally, dividing the levator ani muscles from their lateral attachments to the pelvic wall after first clamping them with large pedicle forceps in order to crush the vessels. Traction made on the loop of the bowel which is drawn into the wound, greatly facilitates the dissection. The lining of the anal canal is dissected out from below as in the Whitehead operation, and the whole segment of bowel along with the attached mucosa of the anal canal is delivered (Fig. 580). The bleeding vessels are controlled by being whipped over with catgut and the wound is closed by eliminating dead spaces as far as can be done without tension with sutures of catgut, lightly packing the spaces that remain with iodoform gauze. Drainage is brought out posteriorly. The skin wound is closed with interrupted sutures of silkworm-gut.

According to C. H. Mayo, this second step should be done in six days. If deferred to eight or ten days a slough often occurs and there may be leakage of the intestinal contents or infection from the cancer. Coffey's method of inserting a tube through the rectum up to the divided bowel, fastening it at this point with sutures, and then inverting the bowel and pulling it down in this way is excellent if the growth is sufficiently small to permit the tube and is not too firmly fixed.

If the cancer is about the middle of the rectum it may be removed by the Mayo modification of the Kraske operation. The exposure is as has been described in the second stage of the combined abdominal and perineal operation. After exposing the rectum by removing the coccyx and the lower part of the sacrum at the second sacral foramen the rectum is mobilized above the disease and the peritoneum opened anteriorly and packed with gauze. The sigmoid is pulled down and the inferior mesenteric artery is divided as close to its origin as possible in order not to interfere with the numerous communicating branches in the distal portion of the mesentery which will permit collateral circulation. The two folds of the mesorectum are opened and all the fat and fascia adjacent to the rectum are pushed downward by

gauze dissection. Its lateral attachments are clamped and cut. The bowel is separated in front from the bladder and urethra in man or from the vagina and cervix in woman. It now lies attached at its upper and lower ends. The bowel is doubly clamped and divided just above the external sphincter and is doubly clamped well above the disease and divided and the diseased segment is removed. The upper stump, which has been clamped, is disinfected with a cautery, ligated with stout silk, and brought down through the anus an inch outside of the anus. It is important that there shall be no tension on the bowel. If there is, the peritoneum must be in-

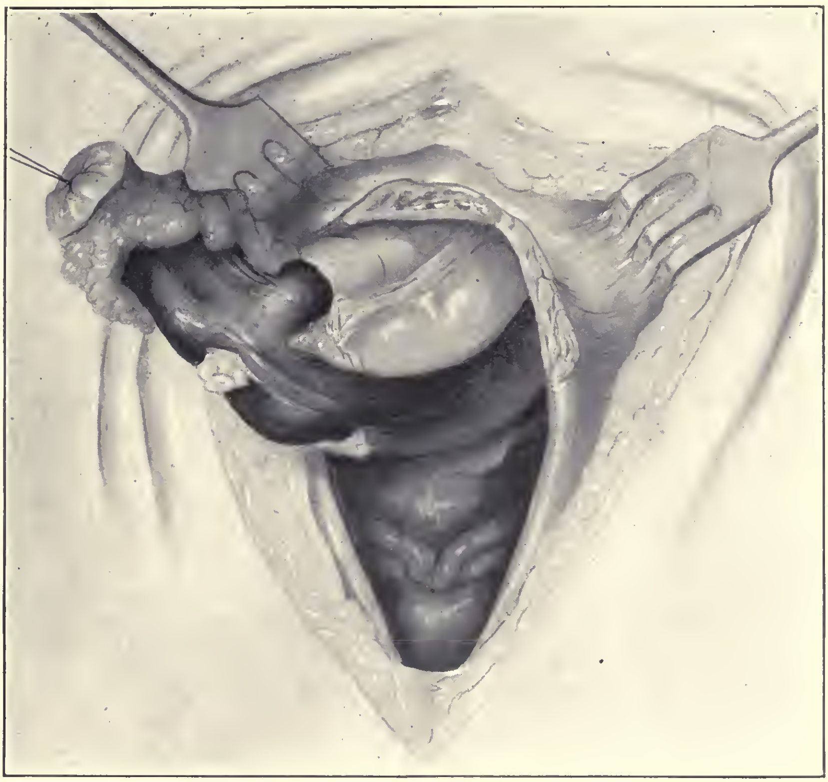

Fig. 580.—The peritoneum has been opened and the lateral attachments of the rectum have been severed. The rectum is drawn down and the sigmoid appears in the wound. The prostate, seminal vesicles and base of the bladder are shown. (After technic of W. J. and C. H. Mayo.)

cised more freely at the side of the sigmoid and the resisting bands severed. The gauze packing in the peritoneal cavity is removed and the peritoneum is attached to the bowel with interrupted sutures. The stumps of the levator ani muscles are sutured to the posterior surface of the bowel. Drainage is provided by a tube and a cigarette drain and the rest of the wound is closed with interrupted sutures of silkworm-gut. The lower end of the bowel may be left ligated for two days or sometimes longer with but little discomfort. This will add greatly to the healing of the wound without infection. At the end of two days the ligature is removed or if the patient is comfortable

it can be left in position still longer. When it is removed a tube is placed in the bowel which will conduct off most of the discharges and so lessen the chances of infection.

Often so much of the bowel is involved that it is unwise to save the sphincters. Here the upper end of the bowel may be brought out through the upper portion of the sacral wound, though this makes an artificial anus that is difficult to clean and is unsatisfactory, so it is probably better to establish an abdominal anus. If this is done it should be according to the method which has been described for the combined abdominal and perineal excision in two stages in which the upper stump of the sigmoid is brought through the split fibers of the rectus muscle and twisted three-quarters of a turn in order to aid in the control of the bowel.

In cancer in the anal canal or of the rectum near the anus the operation is performed as follows: The skin around the anus is incised, reflected toward the anal canal, and fastened with a ligature or suture. From this incision around the anus a straight cut is made anteriorly and one posteriorly. The anus and rectum, with the sphincters, are separated from their surroundings, leaving as much fat and fascia attached to the anus and rectum as possible. Pulling on the ligatured anus aids the dissection. The rectum is mobilized by inserting the fingers posteriorly and stripping the tissues from the coccyx and lower sacrum. The levator ani muscles are clamped and divided on the side and the rectum is separated in front from the urethra in the male as in the first stage of a perineal prostatectomy. A sound is placed in the urethra to prevent injury to the urethra. In woman the posterior vaginal wall may be incised to aid the dissection. The bowel is brought down so that a part of the rectum which is two inches above the apparent margins of the growth is flush with the skin of the anus and can be fastened in this position without too much tension. The stumps of the levator ani muscles and the clamped vessels are sutured over with catgut. If possible, the rectum is twisted slightly according to the practice of Gersuny in order to aid in the control of the bowel. It is amputated and the stump fastened to the skin or as near the skin as possible with interrupted sutures of linen or silk. If cancer of the anus or of the anal canal is fairly advanced both inguinal regions should be dissected, as the lymphatics from the anal canal, especially from its external portion, go chiefly to the inguinal regions.

Occasionally, in early cancer of the rectum when it is low down, the anus may be thoroughly dilated and the tumor seized through a speculum and removed with an electric cautery. Care should be taken to manipulate the tumor as little as possible and the wound should be closed with sutures of stout catgut which will prevent bleeding and which are inserted in such a manner as to decrease the caliber of the bowel as little as possible.

Sometimes when the growth is freely movable and in the lower part of the rectum the sphincter muscles may be preserved by merely dissecting out the mucosa from the lower part of the anus, as in the Whitehead operation for hemorrhoids. After going above the region of the sphincter the external

layers of the bowel wall are cut through and the rectum is mobilized. It is then pulled down, divided above the cancer through its healthy portion and sutured to the skin.

As a rule, too great an effort is made to preserve the function of the sphincter in operations on the rectum. In a very early growth this may sometimes be done, but not infrequently the effort to preserve the sphincter leads to an operation that is not sufficiently complete, and consequently there is an early recurrence.

In cancer of the rectum where as much as eight inches of the bowel must be removed and where the lower margin of the cancer is about two and a half inches from the sphincter ani, the method of Kraske is a satisfactory operation. This may be followed by bringing the bowel through the anus or by a sacral anus, though a permanent colostomy is, as a rule, more satisfactory.

If dissection can be safely made no closer than two and one-half inches to the anus the sphincter may be saved and the bowel ends may be united. The upper end of the rectum is much smaller than the lower end and is largely surrounded by peritoneum. The upper end is split on the surface opposite its mesentery for about one and a quarter inches to make it of the same caliber as the lower portion. It is best to rotate the bowel so as to bring the peritoneal surface posterior. This should be done in such a manner as not to make too great tension on the mesenteric border. Half a turn of the bowel will secure the desired position and at the same time will not interfere too greatly with its nutrition. Through and through sutures of tanned or chromic catgut are placed so as to invert the mucosa, and over this a second row of interrupted sutures of fine silk is inserted. Melted vaseline if poured over the cavity of the wound seems, according to C. H. Mayo, to prevent infection. Drainage from the dead spaces is provided by bringing tubes out through the sacral wound. The sphincter ani is divulsed and may best be put out of commission by dividing it anteriorly with an electric cautery.

In small early cancers in the anterior wall of the lower rectum the procedure as practiced by Bevan[7] seems excellent. Of course, this is only applicable to small beginning cancers that have not infiltrated the whole wall of the bowel and are in the lowest portion of the rectum. The patient is placed face down and with the table broken, similar to the Trendelenburg position, only the patient lies on his abdomen instead of on his back. This position is useful in any sacral operation on the rectum. An incision about five or six inches in length is made from the lower part of the sacrum to the anus in the midline. The coccyx is exposed and excised from the sacrum with bone cutting forceps. The tissues on each side are retracted and, beginning at the anus, posteriorly, the anus and rectum are divided upward for four inches (Fig. 581). The edges of the wound in the rectum are caught with clamps as the division proceeds. If in the course of

[7]Surgical Clinics of Chicago, W. B. Saunders Co., December, 1917, p. 1233, et seq.

dissection no metastasis is found and it is demonstrated that the cancer is early and has not penetrated the bowel wall, it is removed with an electric cautery, going well beyond the apparent margins of the growth and cutting through the whole wall of the rectum until the areolar tissue beneath is recognized (Fig. 582). In a male, a sound in the urethra prevents injury to the urethra. The wound left by removing the cancer is closed by interrupted sutures of linen or stout catgut in a large curved needle which approximate the wound and control the hemorrhage (Fig. 583). The posterior rectal wound is closed, beginning at the upper end of the incision, with interrupted sutures of linen which are tied with the knots inside of the lumen

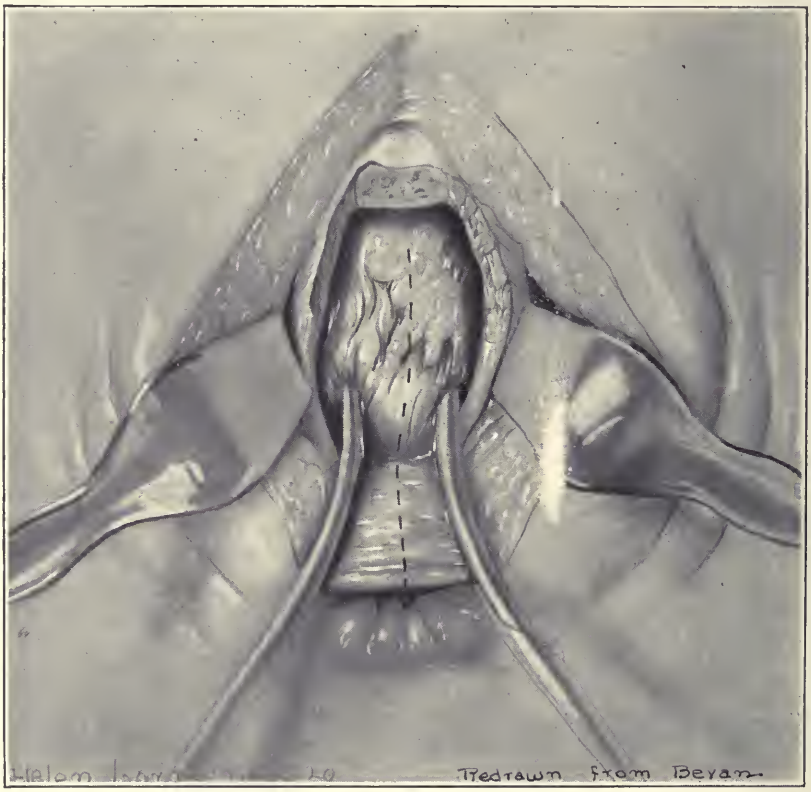

Fig. 581.—Operation of Bevan for early superficial cancer of the anterior wall of lower rectum. The dotted line shows the site of the incision.

of the bowel. Over this a continuous suture of tanned or chromic catgut is placed. A piece of iodoform gauze is packed into the rectum over the region from which the cancer was removed and another piece is placed in the upper angle of the skin wound. The incision in the skin wound is closed with interrupted sutures of silkworm-gut.

For prolapse of the rectum the patient is thoroughly prepared by light diet and mild purgatives for several days before the operation, but no purgative should be given for forty-eight hours immediately preceding the opera-

tion, during which time the bowel is emptied by soapsud enemas and the diet restricted to liquids.

The operation to be done for prolapse of the rectum depends upon the stage of the disease and the condition of the patient. In children most cases can be cured without operation. Attention to the diet, mild laxatives, and avoiding strain at stool will often effect a cure in young children. In adults, a fresh prolapse may be treated by replacement and by strapping the buttocks together with adhesive plaster. An incomplete prolapse, that is, one in

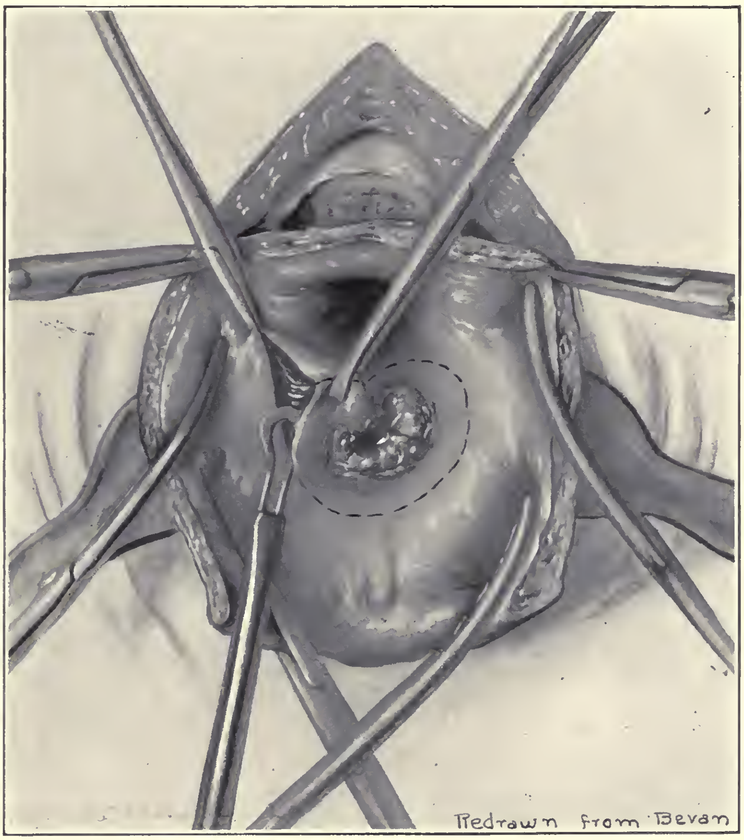

Fig. 582.—The cancer has been exposed and is removed with an electric cautery. (Bevan.)

which the mucosa descends, or a complete prolapse in which all coats of the rectum come down but with the sphincter still retaining some of its power, is very satisfactorily treated by linear cauterization with a thermo or electric cautery. The prolapse is pulled down as far as possible with the patient in the dorsal position, and the cauterization begins at the highest internal point of the prolapse, continues downward, parallel with the axis of the bowel, and terminates just above the sphincter. The cautery should be carried through the mucosa and just into the muscular coat. Four or five of these incisions are made parallel to each other and with a narrow

strip of healthy mucosa between each line of cauterization (Fig. 584). The prolapse is then reduced and the protrusion is kept above the grasp of the sphincter by suturing the anus. Kellogg Speed[8] sutures the anus with a stout silk thread in a curved needle, beginning near the median raphe in front and passing the suture completely around the anus. It is then drawn tight and tied so that not even a grooved director can be inserted into the anal canal. The patient remains in bed and has a diet that will leave as

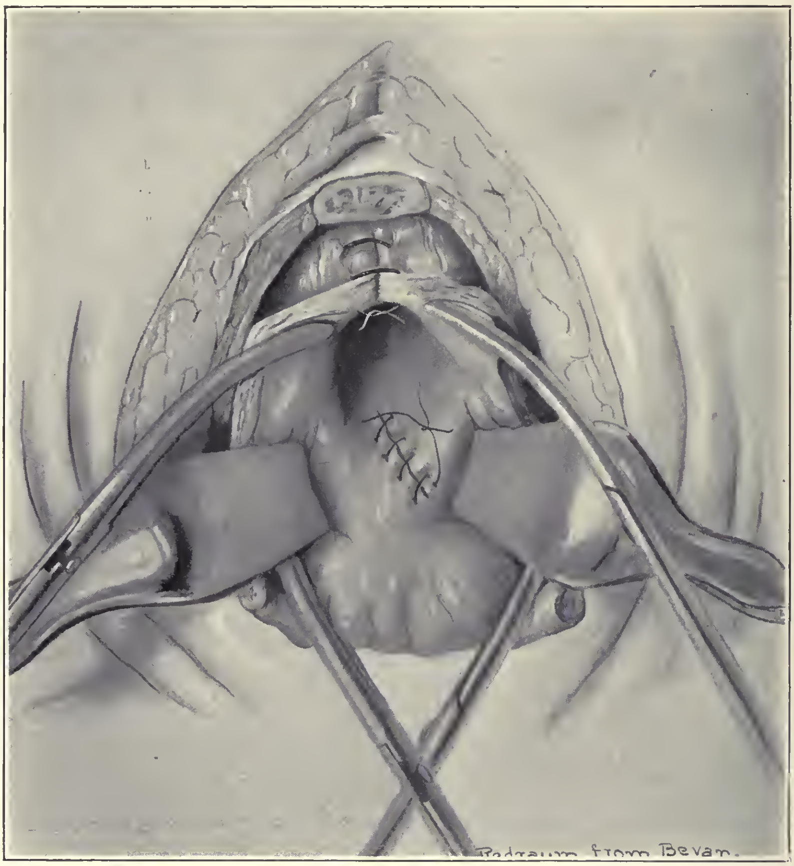

Fig. 583.—The wound left by the excision of the cancer is closed with a few sutures. The posterior wall of the rectum is united with interrupted sutures, tying the knot within the lumen of the bowel. (Bevan.)

little residue as possible. He is given a grain of powdered opium by mouth every day. At the end of a week the pursestring is cut, but the patient is kept in bed for another week, being given magnesia by the mouth to keep the fecal matter soft, and using a bed pan for the bowel movements.

When the prolapse seems to involve most of the lower part of the rectum an incision may be made from the posterior part of the anus to the coccyx.

[8]Surgical Clinics of Chicago, W. B. Saunders Co., February, 1920, p. 68.

The wall of the rectum is sutured to the thick fascia and ligaments in the neighborhood and a reef may be taken in the levator ani muscles. With a complete prolapse and weak sphincter, especially in elderly people, the prolapse is amputated by carefully cutting through the anterior portion of the prolapsed rectum with a transverse incision near the anus and suturing the part of the bowel near the anus to the anterior wall of the upper segment of the prolapsed portion as high up as the sutures can be conveniently placed. Care is taken to avoid injury to any structures that may be in the culdesac and to prevent soiling the peritoneum. This transverse incision is continued, cutting a short distance at a time and immediately suturing what has been cut until the whole prolapsed segment has been removed. These sutures, which are of linen or silk, are reinforced by a continuous suture approximating the mucosa of the bowel.

Fig. 584.—The prolapse of the rectal mucosa is cauterized with electric cautery.

If an abdominal operation seems wiser the operation of Moschcowitz is satisfactory. Here a median abdominal incision is made from the pubis to umbilicus and the patient is placed in the extreme Trendelenburg position. If the prolapse is in a woman, linen or silk sutures are passed in a circular manner around the culdesac of Douglas and tied. The lowest suture is one inch above the bottom of the culdesac. Six or eight sutures are passed, one above the other, placing as many sutures as necessary to bring the peritoneum together without too much tension and so obliterating the culdesac of Douglas. An effort should be made to secure some of the pelvic fascia in each of these sutures, particularly over the levator ani muscles. When the sutures reach the cervix and body of the uterus these structures are included and the peritoneum and muscular coats of the rectum are also grasped in each suture. Care should be taken to avoid the uterine and the internal iliac

vessels. In elderly women the uterus is sewed firmly to the anterior abdominal wall after the culdesac has been obliterated. No fixation of the colon or sigmoid to the abdominal wall is done, as this is useless. The after-treatment is the same as after any other laparotomy. Moschcowitz's operation is based on the theory that prolapse of the rectum is due to relaxation of the pelvic fascia which permits a descent of the rectum, and that sutures placed in the manner indicated will take up the slack in this fascia and afford a firm support because of the close attachment of this fascia to the peritoneum and the readiness with which the peritoneum unites when firmly approximated.

Abscesses around the rectum in the ischiorectal fossa should be opened as soon as the diagnosis can be reasonably made. The incision is so made as to avoid injury to the sphincter, the finger is introduced and the cavity explored. The various compartments are gently broken down and the wound is lightly packed with iodoform gauze. This packing is changed at intervals of two or three days. If the abscess is comparatively small it may be opened under local anesthesia, tube drainage instituted for a few days until much of the reaction has subsided and then the wound is gently packed with iodoform gauze which has been soaked in five per cent solution of balsam of Peru in castor oil. The bowels are kept constipated for a few days, and afterwards mild laxatives are taken to keep the bowel movements soft. Such an abscess may result in a sinus but will heal in a short time. If there is communication with the bowel a fistula will result, but if the sphincter is cut when the abscess is first opened an unnecessary amount of raw surface will be exposed to the pus before the local tissues have acquired sufficient resistance against the infection and serious harm may be done. Incontinence will frequently follow. After the fistula has well formed, however, operation may be undertaken with the hope of more satisfactory results. A fistula may be small and open near the margin of the anus. The opening usually is much nearer the anus than it is supposed to be. If the opening can be readily demonstrated the old operation of introducing a grooved director and splitting the tissues over it, including the sphincter at a right angle to the sphincter, gives satisfactory results, provided the tract of the fistula is dissected out or thoroughly cauterized with the actual cautery. The wound is packed with gauze every day for a few weeks until the granulations have become healthy. The sphincter should always be cut at right angles to its fibers. If cut obliquely, control of the sphincter is often lost, but even after a right-angle section incontinence occasionally results. When this does occur a subsequent operation is done to dissect out the ends of the sphincter and unite them with buried sutures of fine tanned catgut.

In a complicated fistula, particularly of the horseshoe type, the operation as described for simple fistula is unsatisfactory. Complicated fistulas that arise from the posterior half of the anus almost always unite at a common point at the posterior part of the anus. Here the sphincter is divided at a right angle to its fibers and the various tracts are made to communicate.

Packing, which is renewed every day or every two days, together with the usual treatment for control of the bowels, is carried out.

In a few instances the tract of the fistula can be dissected out and the wound completely sutured. This may be done in the simpler fistulas where the tract is well organized and the scar tissue around it presents a definite tube. In a complicated fistula if the opening into the bowel can be closed and the fistula thereby converted into a sinus, the results are often much more satisfactory.

The operation of Elting consists of mobilizing the mucosa of the anal canal and lower rectum as in the Whitehead operation for hemorrhoids and dissecting it free for a short distance above the internal opening of the fistula. The mucosa is drawn down and the excess amputated. The mucosa is then fastened to the skin around the anus with interrupted sutures of linen or silk. Only the mucous membrane with its submucosa is dissected free in this operation and the line of cleavage should be carefully observed, for if the muscular coat is included the operation is more difficult and proper mobilization cannot be effected. The chief objection to the Elting operation is that stricture may result.

E. S. Judd has modified the Elting operation by making the incision only half way around the circumference of the anus on the side of the fistula and extending the dissection well above the internal opening of the fistula. The mucosa of the bowel on this side is pulled down, the excess cut away and the stump sutured to the skin of the anus with silk or linen. This avoids the possibility of a stricture which may occur after a complete circumferential incision of the anus or rectum. The rest of the fistula will usually heal readily if the opening into the bowel has been securely closed. The fistula, however, may be enlarged by an incision parallel with the sphincter, and the tracts curetted and cauterized or dissected out.

In a fistula where the tract is tortuous it is followed much more easily if the fistula is injected with some dye, as methylene blue. This is done by inserting a sharp-pointed syringe filled with methylene blue into the opening of the fistula and gradually injecting the dye until the fistula is well distended. The syringe is held in position for half a minute until the dye is well taken up. This will permit the easy following of the fistulous tract which is opened in all its ramifications and cauterized or dissected out. It must always be borne in mind, however, that the sphincter should never be cut but once and then at right angles to its fibers.

In rectovesical or rectourethral fistula it is essential to drain the bladder, preferably by a suprapubic cystotomy, before attempting to close the fistula. The fistula may be then closed by a plastic operation involving the principle of Elting, which has been very successfully used by Harvey Stone, of Baltimore. The mucosa of the rectum is mobilized to a point well above the opening of the fistula into the rectum and a few sutures of catgut are placed into the urethral opening of the fistula. The cuff of the mucosa is brought down

to the anus, the excess cut off, and the remainder sutured to the margins of the anus.

Fissure in ano is an ulcer in the mucosa of the anal canal and is usually found along the posterior border of the anus. It is about half an inch long. After it has existed for a short time the tissues around it become indurated. There is considerable spasm of the sphincter due to pain, and the spasm also causes pain and prevents healing, so that a vicious circle is established. The passage of fecal matter, together with the more or less constant motion of the sphincter, prevents the healing. The treatment must be directed to secure rest and remove the conditions that cause irritation. The sphincter ani should be paralyzed by gradually stretching it under general anesthetic, or the tissues around the sphincter may be carefully infiltrated with one-half of one per cent procaine solution and divulsion of the sphincter can then be accomplished with but little pain. The injections, however, should be made not only in the sphincter but around the anal canal for a distance of an inch or more toward the rectum. Under local anesthesia the fissure may be cauterized with an electric cautery and the sphincter partly or completely divided in the posterior midline. This sometimes is a more satisfactory treatment than simple divulsion, as it can be done more readily under local anesthesia. There is a small skin tag at the external end of the fissure which is called a sentinal pile.

Operation for ulceration of the rectum depends upon the type of ulceration. If the ulceration is extensive the sphincter should be divulsed or divided, preferably with an electric cautery at its anterior or posterior commissure. The posterior division secures better drainage, though the division anteriorly sometimes heals more satisfactorily. This will aid the healing of an ulcer because it affords rest to the lower part of the rectum by preventing an accumulation of gas or fecal contents which would occur when the sphincter is intact. Ulceration due to cancer should be treated according to some of the methods of excision depending upon the stage and type of the cancer and also upon its location. Ulcers due to syphilis or to the ameba should have specific treatment. Dysenteric ulcers that are high up in the rectum and in the sigmoid are sometimes treated by cecostomy or appendicostomy in which the appendix is brought up through an incision in the right iliac fossa, part of it cut away, and the appendix fixed to the abdominal wound. Its lumen is dilated to admit a catheter through which liquids having a supposedly therapeutic effect on the ulcer are introduced. A cecostomy is done by using the technic for enterostomy with a tube introduced through the wound for irrigating the bowel. These operations, however, for this purpose are being generally abandoned because fluids can be introduced through the rectum with considerable satisfaction, and also because the irrigation of the ulcerated areas with fluid which only comes in contact with the ulcers for a very short time does but little good when the fecal current is permitted constantly to bathe these surfaces. If any operation is done, it should be a complete diversion of the fecal current and this is best accomplished by the

John Young Brown operation in the lower ileum (p. 599). The distal end of the ileum can be used for irrigating the colon and cleaning away the fecal contents that may remain. Without the presence of the fecal current, irrigating solutions may be of some value.

Strictures of the rectum, when cancerous, are treated by resection of the rectum. Stricture is particularly likely to follow a circumferential suture of the rectum when made below the border of the peritoneal covering. Strictures in the lower portion of the rectum or in the anal canal accompanied by dense tissue may be divided by a posterior linear proctotomy. Here the knife is introduced above the stricture and a deep incision is made posteriorly in the midline almost to the tip of the coccyx. Bleeding is controlled by whipping over the bleeding surfaces with sutures and by packing with gauze. By making an incision in this manner drainage is facilitated and by keeping the incision in the midline the danger of incontinence is usually avoided. The first packing must be placed quite firmly to control hemorrhage, but afterwards the packing with gauze should be loose enough merely to fill the cavity lightly. The treatment after the wound has begun healing consists in regular dilatation with soft rubber bougies. A stricture is very likely to occur unless dilatation is kept up for several months after healing.

In obstinate strictures, resection of the lower portion of the rectum by the perineal method, or even the Mayo-Kraske operation, may be justifiable. In benign strictures that are uncomplicated constant dilatation, preferably with soft rubber bougies, will usually effect a cure. The patient can be instructed to pass these bougies first under the surgeon's direction and later by himself. Metal or stiff instruments should be avoided. The bougies are of graduated sizes.

In first inserting a bougie to dilate a stricture of the rectum the method of Tuttle should be employed. A proctoscope is introduced up to the stricture and with an electric light attachment the opening in the stricture is demonstrated and the rubber bougie is accurately inserted. This is left in for a few minutes and a larger size is then introduced. Not more than three bougies should be inserted at the same sitting. After the stricture has been sufficiently dilated the bougie may be passed without the speculum, but at first the use of the speculum and the accurate passage of the bougie may prevent unnecessary trauma.

Bevan[9] operates in strictures that are low down by dilating the stricture fully under a general anesthetic, then freeing the mucous membrane of the rectum to a point just above the stricture, as in the Whitehead operation for hemorrhoids, and bringing it down and uniting it to the anus. If dilatation ruptures the mucosa at the site of the stricture and makes a raw surface, the mucosa above the stricture is brought down and fastened to the margins of the anus with mattress sutures of silk or linen. When the stricture is low and narrow this procedure may be applicable, but it should be followed by passage of bougies or dilatation at intervals for a number of months.

[9]Surgical Clinics of Chicago, W. B. Saunders Co., February, 1918, p. 67, et seq.

HEMORRHOIDS

Hemorrhoids are divided into three classes, external, internal and externointernal. External thrombotic hemorrhoids cause a great deal of pain, which is readily relieved by incision and turning out the clot. This can be done painlessly by the injection of procaine solution with a very fine sharp hypodermic needle. Before injecting the solution the skin over the pile is touched with a probe that has been dipped into pure carbolic. After waiting one or two minutes the hypodermic needle is inserted into this point and there is usually no pain. The incision is made in a radiating manner parallel with the normal folds of the skin about the anus. After the clot is turned out the raw surface is packed with iodoform gauze. If these clots are left they may organize and form tags which are sometimes annoying.

Internal hemorrhoids are venous or capillary. The capillary pile is covered with a very thin layer of epithelium and bleeds easily. It resembles a raspberry. Occasionally a polyp is found which is thought to be a hemorrhoid. Capillary hemorrhoids do not protrude and can hardly be located by touch. They bleed on contact with the instrument for examination and bleed frequently after a bowel movement.

The venous internal hemorrhoid comes from a dilatation of the vessels that lead to the superior hemorrhoidal vein and occurs just within the sphincter. This type may be associated with venous external hemorrhoids and both can be treated in the same manner. When there is no complication about the internal hemorrhoid and the sphincter is not too tight, treatment can often be carried out in a satisfactory manner by the method of injection with a solution of quinine and urea, which has been devised by E. H. Terrell, of Richmond, Va. He uses a solution of quinine and urea of three to five per cent strength and occasionally as strong as ten per cent, the weaker solution being given in the first injections. Usually there are three hemorrhoids to be treated and one is injected on each succeeding day until all are treated. If the hemorrhoids are prolapsed they are replaced before treatment is begun. The hemorrhoid to be injected is brought into view through a small conical fenestrated speculum and is painted with equal parts of tincture of iodine and alcohol. Terrell uses a very small needle and a hypodermic syringe such as is employed in giving tuberculin so that it will not block the vision. The needle is inserted well into the substance of the pile and the solution is injected slowly until the pile is slightly distended. The needle is held in position a moment to prevent bleeding at the point of puncture and is then quickly withdrawn. On the following day the hemorrhoid on digital palpation is felt to be thickened and indurated. After three or four days it begins to subside. If the hemorrhoid still persists after ten days or two weeks, the treatment is repeated, using a slightly stronger solution. This treatment should be persisted in at intervals of ten days or two weeks until the piles have disappeared. There is practically no pain from the treatment and the patient is permitted to pursue his usual vocation, though it is usually

best to rest for a few hours after each injection. If by chance the solution is injected into or immediately beneath the mucosa instead of into the body of the pile, ulceration and necrosis may occur, but this accident is easily avoided by injecting the solution into the upper part of the body of the pile when the effect of the quinine and urea on the blood vessels and surrounding tissues will not extend to the surface of the mucosa.

It must again be emphasized that the Terrell method of injecting hemorrhoids with quinine and urea solution, which has just been described, is only applicable in uncomplicated hemorrhoids, that is, when there is no strangulation or abscess formation, or when the sphincter is not too tight. It may, however, be successfully used when the hemorrhoids bleed.

When the piles are large and, particularly when the patient desires a quick and radical cure, operation must be done. There are three different operations that under different conditions are applicable and are followed by good results. The oldest of these methods and one that is frequently employed with a local anesthetic is ligation and excision. The pile is caught with forceps, pulled down, and the mucous membrane at its lowest border is divided with scissors close to its junction with the skin. This incision is carried upward on each side and then the pile is separated from the tissues beneath by inserting the scissors closed and separating the blades. When the dissection has been carried upward until the hemorrhoid is attached by a pedicle composed of the blood vessels and a small strip of mucosa, the pedicle is crushed with forceps and tied with linen or silk. The hemorrhoid is cut off about one-quarter of an inch below the ligature. Each hemorrhoid is treated in a similar way, taking care to see that there is a small strip of healthy mucosa left between each hemorrhoid. The sphincter ani must be dilated for this operation, though not as thoroughly as would be necessary for clamp and cautery. General anesthesia would be preferable if there are several hemorrhoids to be ligated. The objection to this operation is that it may be followed by infection and sometimes by secondary hemorrhage. The raw surface left cannot be protected from the bowel contents and if infection begins and abscess formation occurs, complications that are annoying and sometimes grave may arise. When the operation can be followed by rest in bed in a hospital and when the diet is regulated and careful attention is paid to the after-treatment these complications may, as a rule, be avoided.

One of the most satisfactory operations for hemorrhoids is the clamp and cautery. If properly performed it does not result in stricture. After ligation and excision there is a certain amount of necrosis and the raw surfaces must necessarily be bathed with fecal matter, but with the clamp and cautery the heat sterilizes the tissues and seals the wound with an aseptic eschar. The operation is simple though it should be carefully done in order to secure the best results. After thoroughly dilating the sphincter, each hemorrhoid is caught at its apex with a hemostat and dragged well down through the anus. It is clamped with Ferguson's pedicle forceps, parallel with the anal folds (Fig. 585). These forceps have blades that are flat and hold

the hemorrhoid firmly. No skin is included within the bite of the forceps. It is best not to make an incision with scissors or a knife because this will leave a raw surface that may be a portal of infection. The object of the clamp and cautery operation should be to have the whole wound thoroughly covered with an aseptic eschar. With a little care a good hold can be obtained upon the hemorrhoid without including the skin. Usually the hemorrhoids are grouped in three locations and three clamps will include all the piles necessary to be removed. It is particularly important to see that there is

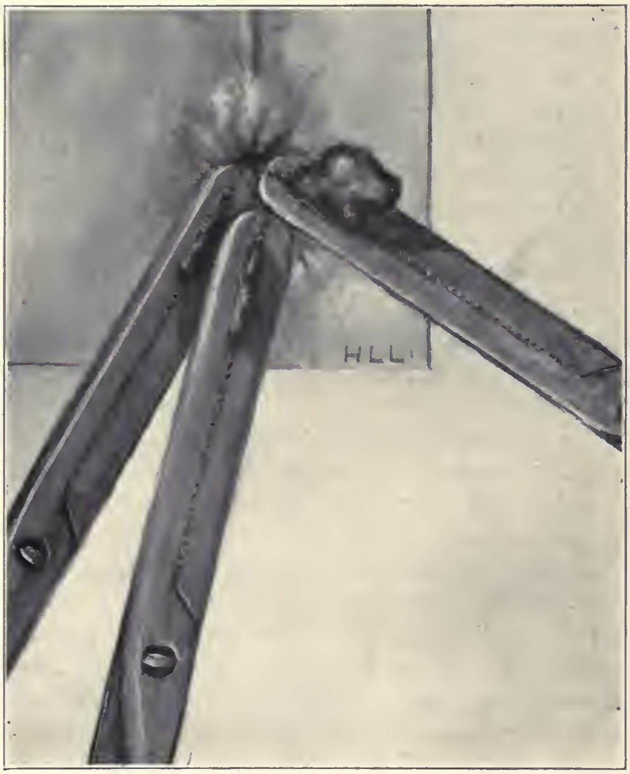

Fig. 585.—Clamp and cautery operation for hemorrhoids. The hemorrhoids have been clamped with Ferguson forceps and two have been removed with cautery.

a broad strip of healthy mucosa between each clamp. If this precaution is taken, stricture will not result.

After all the piles are clamped the last one is pulled down so the tip of the Ferguson forceps emerges from the anus. To protect the surrounding tissues from heat wet gauze is wrapped around the base of the hemorrhoid just beneath the forceps. In the original operation the whole hemorrhoid is cauterized with the actual cautery. This is necessary when a special pile clamp, such as Smith's, is used, because after one hemorrhoid has been cauterized the clamp is taken off and applied to another. In this way the eschar is often broken by the manipulations, and bleeding results. The

Ferguson clamps, however, are left on until the completion of the operation, hold the eschar firmly and so prevent this accident; consequently, time can be saved and satisfactory results obtained by cutting off the hemorrhoid, if it is large, either with scissors or cautery about a quarter of an inch from the clamp. The tissues being thoroughly protected from the heat with wet gauze, the stump of the hemorrhoid is cooked with a thermo or an electric cautery at a low heat. The cautery is applied not only to the hemorrhoidal stump, but slightly to the forceps near the stump, so that a low degree of heat will be conveyed to the pedicle of the hemorrhoid that is within the grasp of the forceps. About one minute is devoted to cauterizing each hemorrhoid.

The wet gauze is removed and the next pile is treated in a similar way. After each cauterization the clamp is not removed but its tip is returned

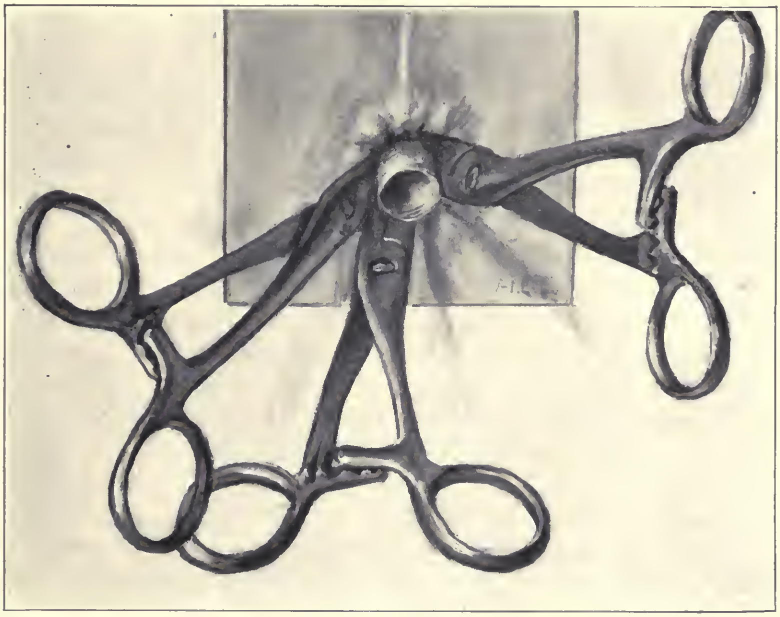

Fig. 586.—Clamp and cautery operation for hemorrhoids. The hemorrhoids have been removed with cautery, a tube is inserted, and the clamps are about to be removed. The tube is usually well wrapped with gauze and the gauze covered with rubber dam. This is not shown in the drawing.

into the anus and gently pushed up into the rectum so that the forceps will be out of the way while the next hemorrhoid is being treated. After all of the piles have been cauterized a rather firm rubber tube about three inches long and one-third of an inch in internal diameter is wrapped with iodoform gauze, covered with rubber dam, anointed with sterile vaseline, and inserted into the anal canal (Fig. 586). A safety pin is fixed in its outer end. Each Ferguson clamp is then removed gently to avoid breaking the eschar. The tissues are dusted with bicarbonate of soda and gauze is wrapped around the outer end of the tube under the safety pin to prevent the safety pin from pressing on the anus. A strip of adhesive across the

buttocks anchors the tube and safety pin more firmly. A pad and a T bandage are placed over the end of the tube. If the cauterization is carefully done and if the tube is inserted and forceps are removed without breaking the eschar, there is practically no danger of hemorrhage after this operation. Stricture is avoided by leaving a sufficient amount of healthy mucosa between each clamp. The scar tissue that forms after a burn is notoriously greater than that from an incision and so tends to obliterate any dilated vessel in its neighborhood that may not have been caught in the Ferguson clamp. The tube gives exit for gas and thus makes the patient more comfortable. Five or six small punctures in the skin of the anus about half an inch deep along the outer border of the sphincter lessen the swelling and permit the escape of serum and the venous blood that has become congested in the tissues.

The Whitehead operation for hemorrhoids is very rarely indicated. It is not only more formidable than the clamp and cautery and more difficult to execute, but is peculiarly likely to be followed by stricture, which is a much worse affliction than hemorrhoids. Occasionally, however, in very aggravated types of hemorrhoids when their borders are not well defined and particularly when they are associated with prolapse of the mucosa the Whitehead operation is justifiable. After preparing the patient in the usual way and dilating the sphincter, several large hemorrhoids are clamped with forceps, pulled down, and an incision is made around the anus at the junction of the skin and mucosa. The mucous membrane is separated from the sphincter by inserting the scissors with closed blades and spreading them open and by occasionally cutting any marked adhesion that may be present. Blunt dissection with gauze may be used after the mucosa has been partly separated. In this manner a cuff of mucosa from the anal canal and lower rectum is pulled down for about three inches. This includes the pile-bearing area of mucosa. This cuff is cut away in small sections, beginning in front with a transverse incision of half an inch and suturing the upper edge of the mucosa to the skin with interrupted sutures of silk, linen or stout catgut. After this segment has been sutured the incision is continued for another half inch and this part of the mucosa is sutured, and so on until the whole cuff of mucosa has been amputated and its margin has been sutured to the skin. By cutting a small section and suturing it in this manner, more accurate approximation is attained and retraction of the mucosa is prevented. If there are any bleeding points they are controlled by an extra suture. A rubber tube is prepared and inserted as after clamp and cautery. It is also well to make a number of short stab wounds around the outer margin of the anus, a procedure which has been advocated and practiced by C. H. Mayo.

Incontinence of feces may result from injury to the sphincter ani either from childbirth or following operations for fistula. After the inflammatory infiltration has subsided this condition may be corrected by exposing the ends of the divided sphincter and dissecting them for a distance of half an inch on each side. They are then approximated with a mattress suture of fine tanned catgut and this is reinforced by two or three other sutures of the

same material. The skin is closed with a continuous mattress suture of fine tanned catgut. A small rubber tube is introduced through the anus to give exit to gas. The patient is kept constipated for five or six days or even longer if possible with comfort. This can be done by giving a diet that will leave but little residue, such as albumens and broths, and by administering paregoric or, if necessary, opium or morphine when there is an inclination for the bowels to move.

PRURITUS ANI

One of the most annoying affections of the rectum that require operation is constant itching. This may be so severe that an operation is demanded in order to relieve the patient of an intolerable situation. Mild cases

Fig. 587.—A sinus in the anal canal (E. H. Terrell).

may be relieved by ordinary remedies or salves, but in the obstinate cases of pruritus ani local applications are merely palliative.

E. H. Terrell,[10] of Richmond, has had considerable success with splitting the pockets that are found in the lower end of the anal canal. These lesions, he says, are sometimes difficult to find and may be blind pockets or sinuses with their openings at or just internal to the anorectal skin line. Little pockets, or diverticula, as anal valves in this region are frequently normally

[10]Terrell, E. H.: Southern Med. Jour., February, 1920, pp. 123-125.

found but when they are not inflamed or infected they cause no trouble, just as a normal appendix gives no symptoms. When, however, they are chronically infected they are apparently a focus of toxic material that seems to cause the itching. A bent probe, used by Terrell, as shown in the illustration, will often demonstrate these pockets or sinuses (Fig. 587). If the diverticulum is large and forms a pocket instead of a straight sinus its lining is glistening in appearance in its upper part, which is very distinct from the pink mucous membrane immediately above it. The opening of the pocket should

Fig. 588.—A large pocket or diverticulum in the anal canal (E. H. Terrell).

be looked for at the anorectal line. When the covering of this pocket is removed an ulcerated area, which heals slowly, is found (Fig. 588). Terrell removes the covering of the pocket with an electric cautery. Its floor is injected and incised so that a small portion of the superficial sphincteric fibers is divided to promote healing as in fissure in ano. When there is a sinus it sometimes begins at the bottom of the anal valve but is usually found as a slight depression just below the level of the anal valve. A bent probe introduced into such a sinus passes down under the skin, ending in a blind pocket which often appears as a tag of skin or an external pile, but sometimes causes no protuberance (Fig. 587). If the itching is localized to one part of the anus, only one sinus usually exists, but in the severer forms where the itching is general around the anus two or more sinuses or a pocket and a sinus may be found. It is necessary to remove completely the covering from the pocket, though the sinus may be simply laid open from

its orifice to its termination under the skin and any redundant skin or mucosa trimmed away (Fig. 589). Opening the sinus is best done with a small electric cautery. The wound is inspected and packed so that it heals from the bottom. Healing is often slow because of the contraction of the sphincter. The operation can ordinarily be well done under local anesthesia, but if general anesthetic is used, the sphincter should be divulsed which will undoubtedly hasten healing. This method of treatment, which has yielded such excellent results in the hands of Terrell, requires careful searching for the

Fig. 589.—Removal of the covering of one of the anal pockets, according to the method of E. H. Terrell.

pocket or sinus under a good light, but it seems far preferable to operations which are devised to treat the symptoms by destroying the nerves instead of relieving the cause by removing the focus of infection.

SACRAL AND COCCYGEAL DERMOIDS

Dermoids or coccygeal cysts are not infrequently found posterior to the anus. If they have become infected they are often treated as a fistula and opened into the rectum. Such an operation, of course, is useless and never curative. Excision of the complete sac, including the epithelial bearing tissue, is necessary for cure. When a sacral dermoid appears over the lower part of the sacrum, a wide excision of the affected tissue is necessary for cure. The skin should be closed with interrupted mattress sutures of silkworm-gut which are so placed as to evert the edges of the skin and prevent the tendency

to a folding in of the epidermis along the edges of the skin wound, which may be responsible for a recurrence. A dimple appears over the tip of the coccyx in many infants and in about five per cent of adults. Sometimes it is so deep as to form a sinus which readily becomes infected. Such a sinus should be treated as a dermoid and the epithelial lining completely excised together with a considerable amount of surrounding tissue. If this is not thoroughly done recurrence must be expected. Any suspected fistula posterior to the rectum should be examined for hair and the history of the condition carefully obtained. If the patient states that hair has been passed from the fistula it must be regarded and treated as a coccygeal cyst or fistula, and not as a fistula in ano. If there is any reasonable doubt as to the diagnosis it is best to treat the condition as a dermoid and not as a simple fistula in ano.

CHAPTER XXVIII

OPERATIONS ON THE KIDNEY, URETER AND BLADDER

THE KIDNEYS

Incisions for exposure of the kidney have been mentioned but as they are so important in the technic of kidney operations they should be considered at some length. Personally, I find that three incisions for exposing the kidney cover all indications for operations on this organ. Two are lumbar incisions. The simplest of these, the vertical incision of Simon, may be used in operations for fixing the kidney or for a simple exploration in a thin patient. This incision is made along the outer edge of the erector spinæ muscle and goes vertically from the last rib downward to near the crest of the ileum. The fibers of the latissimus dorsi are separated and retracted but not cut. The erector spinæ muscle is retracted inward and the sheath of the quadratus lumborum is opened along the length of the wound. The incision approaches the lower rib but if carried too close to the rib the pleura may be injured. This accident, however, can usually be avoided by pushing the tissues out of the way and by separating the tissues chiefly by blunt dissection up to the lower border of the rib. The transversalis fascia is recognized and opened at the upper part of the wound and the fatty capsule of the kidney bulges into the wound. The iliohypogastric and ilioinguinal nerves lie between the quadratus lumborum and the kidney and are protected by careful retraction outward and downward. They should also be recognized when the wound is closed so they will not be included in the bite of the suture. This incision is very satisfactory for exposure or fixation of a loose movable kidney in a thin person or for removal of a stone in such an individual. As a rule, however, when operation for stone is indicated, or when the kidney is to be removed, a more extensive lumbar incision should be made.

The lumbar incision of W. J. Mayo gives excellent exposure. This is made by beginning about two and one-half inches external to the dorsal spine along the outer margin of the erector spinæ muscle well above the twelfth rib. The incision is carried downward and slightly forward along the anterior margin of the quadratus lumborum to about an inch above the crest of the ileum where it curves forward parallel to the crest of the ileum (Fig. 590). It is carried as far forward as the indication may demand. After dividing the skin and superficial and deep fascia, the posterior superior lumbar triangle just beneath the twelfth rib is opened by cutting through the external and internal oblique, the transversalis and the latissimus dorsi muscles and so exposing the lumbar portion of the transversalis fascia. This fascia

is freely incised, the ilioinguinal and iliohypogastric nerves are identified and retracted out of the way and the lower part of the incision is completed. The posterior part of the twelfth rib is cleared backward and upward almost to the articulation of the rib with the twelfth dorsal vertebra and the pleura is pushed upward. When the attachments of the quadratus lumborum and the lateral arcuate ligament which binds down the twelfth rib are divided, the twelfth rib can be retracted upward and outward which gives an excellent exposure. The edge of the erector spinæ muscle is retracted toward the spine. This incision can be used for all operations upon the kidney in which the kidney is not more than two or three times its normal size

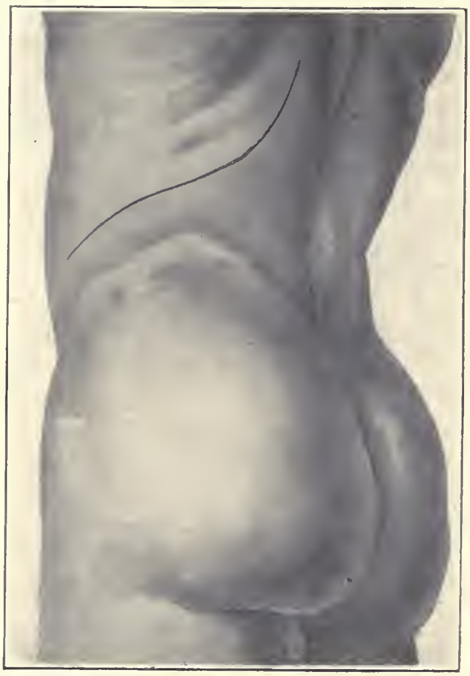

Fig. 590.—The incision of W. J. Mayo for operation on the kidney.

and where the procedure is more extensive than merely fixing a floating kidney or removing a small stone in a thin patient.

When the kidney is considerably larger than normal, and especially in large tumors of the kidney, an anterior abdominal incision should be made. This, called the incision of Langenbuch, begins just below the rib about three inches from the midline and is carried downward along the outer border of the rectus muscle in the linea semilunaris. The peritoneum is opened and the opposite kidney is examined with the hand before proceeding with the operation. The colon and its mesentery are retracted toward the midline and the kidney is exposed.

Nephropexy, or suturing a floating kidney in place, is an operation that

is seldom indicated. It formerly had great vogue and many symptoms caused by nervous conditions, or by stasis or intraabdominal lesions were supposed to be due to a movable kidney. Occasionally, however, when excessive mobility of the kidney may cause it to be damaged, or where symptoms result because of traction or twisting of its pedicle or from kinks in the ureter nephropexy is indicated. When this operation is demanded the patient is always thin and the vertical incision of Simon can be satisfactorily employed. After exposing the kidney with the patient either prone or well over on the opposite side, the kidney is delivered into the wound and its fatty capsule which is scanty in these patients, is stripped backward and downward. It should not be removed for, as has been pointed out by Willard Bartlett, if the fatty capsule is shoved to the lower portion of the kidney it affords some support. The capsule of the kidney is carefully in-

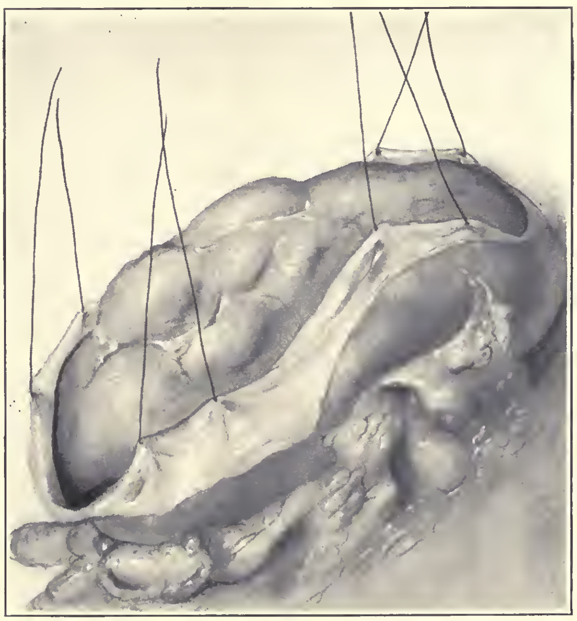

Fig. 591.—Nephropexy. The sutures for fixation have been passed and the kidney is ready to be returned into position.

cised in the midline and is bluntly stripped until about two-thirds of the renal surface is exposed. Four sutures of tanned or chromic catgut are placed in the capsule as mattress sutures, two being near each pole. They are passed from the surface next to the kidney and close to the reflected capsule, catching a wide bite in the capsule. The needle is unthreaded and the ends of the sutures are left long and clamped (Fig. 591). The kidney is replaced and the ends of the upper suture are threaded into large curved needles and passed through the abdominal wall from within outward, penetrating all the structures except the skin. The needle is first inserted in the extreme upper margin of the wound so that the upper pole of the kidney will

be drawn up under the twelfth rib when the sutures are tied. The lower sutures are passed in a similar manner, avoiding the ilioinguinal and iliohypogastric nerves. The sutures are tied after all of them are placed and while they are held taut to bring the denuded cortex of the kidney in close contact with the abdominal wound when it is closed. The wound is closed with interrupted sutures of catgut. While the kidney is brought well up to the upper angle of the wound it is still not as high as it would normally be, but if it retains the position in which it is sutured the result will be satisfactory if the symptoms have been due to the mobility of the kidney. Some operators advocate fixing the kidney by passing the upper sutures around the twelfth rib. This should not be done unless there has been a recurrence, or unless the case seems to require unusual measures. Sutures should not be passed through the substance of the kidney itself, as they will cause a destruction of a certain amount of renal substance and this tissue does not hold sutures well. A sufficiently firm grasp can be obtained by passing the sutures through the reflected capsule of the kidney as mattress sutures.

In nephrectomy for a condition in which the kidney is not much above the normal size the lumbar route is very satisfactory. After exposing the kidney by the incision of Mayo, the fatty capsule is split and bluntly dissected away. It is important to recognize the true capsule of the kidney after splitting the fatty capsule. The kidney is seized with the hand and by gentle traction, delivered into the wound. By strong retraction of the abdominal wound the pedicle is recognized. Fat is carefully separated from the renal artery and vein. If the pedicle is sufficiently long a ligature of catgut is carried around the renal artery and vein together and tied. The ligature should be placed as far from the kidney as possible and then a second ligature toward the kidney is placed half an inch from the first ligature. The ureter is separated from the rest of the pedicle and a clamp is applied to the renal artery and vein close to the kidney to prevent soiling with reflux blood. The renal vessels are divided close to the clamp, leaving the kidney attached solely to the ureter. As much of the ureter as is thought necessary is stripped up and the ureter is doubly ligated with catgut at the lower angle of the wound and divided between ligatures, preferably with a cautery. Not infrequently, there are anomalous polar arteries which must be identified and tied. Often when the pedicle is difficult to expose it cannot be satisfactorily ligated before the kidney has been removed. Here the pedicle is treated by seizing it with two forceps, as practiced by W. J. Mayo, after the ureter has been divided between two ligatures. The stump of the ureter is disinfected and in tuberculosis five to ten minims of carbolic acid are injected into the lumen of the distal part of the ureter with a hypodermic syringe. This in the practice of Mayo has been satisfactory when the ureter was tuberculous and there was no mixed infection. It is better to inject the carbolic acid before the ureter is clamped or tied. The portion of the ureter attached to the kidney is dissected up

well to the pelvis of the kidney so that it will not be included in the clamp on the pedicle. As much fat as possible is removed from the pedicle and then the pedicle is clamped with two forceps about three-quarters of an inch apart and another forceps near the kidney. The kidney is cut away by severing the pedicle between the distal two forceps. A catgut ligature is thrown around the pedicle beneath the deeper pair of forceps and is tied as this clamp is slowly unlocked so that it sinks into the groove made by the forceps. A second ligature, which is placed with a needle that transfixes the pedicle, is tied while slowly removing the distal forceps. Both ligatures are of catgut. The first knot is single and may be held with mosquito forceps to prevent slipping while running down the second knot. If the nephrectomy is for sepsis or tuberculosis the infiltration of the tissues may make it impossible or unwise to ligate the renal vessels separately and the support of the surrounding tissue which has been crushed by forceps in the manner indicated adds to the safety of the ligatures. If on account of the obesity of the patient or the shortness of the stump it is impossible to apply two forceps, one forceps may be used and the ligature passed through a margin of the pedicle and tied in a single knot in order to fix it in position. The ends of the ligature are then carried around the pedicle and securely tied in the groove left by the forceps. This procedure, however, W. J. Mayo has not found necessary in ligating the kidney pedicle for he has always been able to use the two forceps method. Occasionally instead of a ligature, the forceps may be left on and removed after forty-eight hours.

The treatment of the pedicle in a nephrectomy is an exceedingly important part of this operation, first, because of the control of hemorrhage, and, second, because if the nephrectomy is done for a malignant tumor of the kidney, fragments of this tumor may project into the renal vein and if the pedicle is not carefully dissected and secured close to the vena cava at as early a stage in the operation as it can be exposed, manipulations may dislodge some fragments of the growth and force them into the renal vein. It is probable that this accounts for the early hematogenous metastases that occur after nephrectomy for hypernephroma. If the vessels are injured and the bleeding is profuse, pressure with a large piece of dry gauze should be made immediately over the bleeding point. If this controls the bleeding the edges of the gauze are gradually removed until the bleeding points are exposed and clamped. If the hemorrhage is arterial the suggestion of W. J. Mayo should be followed and the injured vessel siezed with the fingers. Pulsations of the artery and of the blood stream will lead the fingers to the injured artery. A clamp can then be applied safely. It is a great mistake to attempt to clamp blindly in this region and forceps should not be applied until the bleeding point has been accurately located. Injuries to the vena cava and to the duodenum from indiscriminate and blind clamping may occur and may be fatal.

If the nephrectomy is for a kidney that is infected with pyogenic bacteria and if there is also some lesion of the bladder and of the other kidney the

ureter may be brought into the lower angle of the wound, stitched to the skin, and left open. Mayo, who suggests this treatment, says that the ureter may discharge for a few days or even weeks, but will soon heal spontaneously in most instances and when it does not heal it can be removed at a secondary operation. This treatment of the ureter, of course, is only indicated where there is marked infection with pyogenic germs and where the dropping of the stump of the ureter into the depth of the wound may cause infection of the whole wound. Before closing the wound the pedicle is examined and the whole field of the operation reviewed to see if the peritoneal cavity has been opened or any injury has been done to the duodenum or colon. It is safer to apply drainage either with a tube or a cigarette drain at the upper angle of the wound. The wound is closed in layers with tanned catgut, using a continuous lock stitch, or with interrupted sutures of silkworm-gut, but always taking care not to include the ilioinguinal or the iliohypogastric nerves in the sutures. If there is no infection drainage can be removed in three days.

The method of procedure during different stages of lumbar nephrectomy depends largely upon the indications for the operation. If done for a malignant growth the chief point is to expose and tie or clamp the renal blood vessels as soon as possible and as far from the kidney as can be safely done. This will prevent metastasis and the ureter may be attended to later, unless its location renders it difficult to secure the blood vessels of the pedicle before severing the ureter. When there is marked sepsis a double catgut ligature is placed on the ureter as far from the kidney as possible to occlude the ureter and prevent forcing an unnecessary amount of septic material into the bladder. The blood vessels can then be secured and divided, leaving the kidney attached solely by the ureter. The ureter is surrounded by moist gauze and divided with a cautery between the ligatures after being injected with carbolic acid. The changes that have been indicated may be adopted according to the indications that arise.

In some old tubercular kidneys, or in old infected kidneys with stone, delivery of the kidney into the wound is exceedingly difficult. Here subcapsular nephrectomy is indicated. If there has been no previous operation and if no sinus or fistula exists the lumbar incision is made down to the capsule of the kidney and the capsule is split along the outer border of the kidney and stripped down to the pelvis. Here, according to the method of Federoff as used by W. J. Mayo, the capsule is divided near the pelvis of the kidney and pushed back, leaving the capsule attached to the fat and the tissues in its neighborhood. The ureter is doubly ligated, and the vessels of the pedicle are exposed. In such cases it is occasionally difficult to secure the pedicle by ligature, partly because of the infiltration of inflammatory products which necessitates the subcapsular method of removing the kidney. Here the pedicle may be clamped with a stout pedicle forceps. The clamp is left on two or three days and is then unlocked but left in position twelve hours longer, when, if there is no bleeding, it is gently removed.

When the kidney is much enlarged and particularly from malignant growths the nephrectomy should be done through an anterior abdominal incision. Ample exposure is made by the incision that has been described along the linea semilunaris. The peritoneum at the root of the outer mesentery of the colon is incised and the colon with its mesentery is mobilized by gauze dissection and pushed toward the midline. The intestines are kept out of the way and protected by packs of warm moist gauze. The pedicle of the kidney is approached if it is possible to do so before any effort is made to mobilize the kidney. The renal vessels are exposed by careful dissection and tied with two catgut ligatures half an inch apart, the inner ligature being close to the vena cava. The vessels are next clamped near the kidney and the pedicle is divided. If this procedure is impossible on account of fat or infiltration of tissue the two forceps method as described in lumbar nephrectomy is used. The kidney is then mobilized, keeping a sharp lookout for anomalous arteries and veins. With a large tumor the adhesions may be very vascular and thin walled veins often develop along the adhesions. The ureter is doubly ligated and divided with a cautery as the last step of the operation, though it may be well to place a double ligature around the ureter immediately after securing the pedicle in order to prevent forcing infectious or malignant material into the bladder. The ureter is divided after the kidney and its tumor have been delivered. With a sufficient incision and careful exposure it is not often necessary to tap a tumor of the kidney before its removal and whenever this is done the danger of infection or metastasis is greatly increased.

The wound is carefully reviewed to see that no accidental injury has occurred and all bleeding points are secured with catgut ligatures. Drainage is established by inserting a pedicle forceps into the cavity left after removing the kidney and pushing the forceps through to the back just external to the margin of the quadratus lumborum until the skin is reached. The skin is then incised over the tip of the forceps after separating the blades and the forceps are thrust through this skin incision and grasp a soft rubber tube about one-third of an inch in diameter which is drawn into the wound. The tube is fixed to the skin by a suture.

The tube should project only about an inch into the cavity left by removing the kidney. The posterior parietal peritoneum is sutured to the outer divided layer of the mesentery of the colon by a continuous suture of catgut. The abdominal incision should be closed with interrupted sutures of coarse silkworm-gut.

In congenital cystic kidneys the disease is usually bilateral and the chief damage is probably done by pressure of a large number of cysts upon the secreting substance of the kidney. Lund has operated successfully in such cases by exposing the kidney and puncturing the cyst through the posterior surface of the kidney. As the cysts are punctured the kidney diminishes in size and can be delivered into the wound, when other cysts are palpated and emptied with a large aspirating needle or a small trocar and cannula. The

kidney is returned to its bed without drainage. Because congenital cystic disease of the kidney is usually bilateral, a nephrectomy should never be done unless it has been thoroughly established that the condition is unilateral and that the other kidney is functioning satisfactorily.

Before any operation upon the kidney and, particularly, before a nephrectomy is done the condition of the supposedly healthy kidney should be carefully ascertained by catheterizing the ureters and examining the urine from this kidney. Except in grave emergencies a nephrectomy is not justified unless this is done. In abdominal nephrectomy advantage should also be taken of the incision to palpate the healthy kidney before the diseased one is removed.

In nephrectomy following a previous nephrotomy there are naturally many adhesions. After making the usual incision and surrounding the fistula the capsule is best reached by splitting the fistula down to the cortex of the kidney and then stripping the capsule and proceeding as has been described with a subcapsular nephrectomy.

Operations for stone in the kidney are done either by splitting the kidney and extracting the stone through the renal cortex or by pyelotomy. Splitting the kidney, or nephrotomy, involves considerable hemorrhage and destruction of some of its parenchyma. This operation should be reserved only for those stones deep in the substance of the kidney or for very large stones that cannot be extracted through the pelvis without too great damage. The average stone can be removed from the pelvis of the kidney if satisfactory exposure is obtained.

The kidney is exposed, preferably by the Mayo incision, and is delivered into the wound. The kidney and its pelvis and ureter should be palpated to determine the pathology present. It is then surrounded with moist gauze. Some operators temporarily clamp the pedicle with soft forceps or surround it with a rubber band to prevent hemorrhage during the incision into the kidney. It has been shown, however, that a kidney withstands suspension of its circulation very poorly and such measures are not advisable. If the hemorrhage is profuse an assistant can usually control it for a short time by pressing with his fingers on the hilum of the kidney, using the fingers of one hand in front and of the other behind. This pressure can be relaxed if necessary to restore circulation or altered to suit the circumstances. If the Broedel line is followed the hemorrhage is greatly lessened. Broedel has shown that the arteries in the cortex of the kidney are distributed into an anterior and posterior group and that the anterior group is wider than the posterior. The vessels of these two groups to the renal cortex are smallest in size and least in number on a line slightly posterior to the external convex border of the kidney, because the anterior group of vessels supplies a little more than half of the organ. If it is impossible to deliver the kidney into the wound, as sometimes occurs in fat people or where the pedicle is short, too much traction must not be made on the pedicle, but the finger is passed under the kidney to

bring its convex border into the wound. An incision is then made slightly posterior to the apex of the convex border and just long enough for the finger to be passed into the pelvis. The stone is located and removed with forceps. The wound in the kidney is closed with interrupted sutures of stout plain catgut, preferably bringing a small tube out through the middle of the wound but suturing the kidney substance around it as snugly as possible. A mattress suture in the kidney controls the hemorrhage better than an ordinary single stitch but it has been demonstrated experimentally by James E. Moore and J. F. Corbett that the mattress suture produces more injury to the kidney substance than a simple interrupted stitch. If the suture is tied just snugly enough to approximate the incision and the first tie of the knot is held with mosquito forceps while the second tie is being run down, hemorrhage will be controlled, the kidney wound coapted, and a minimum of damage will be done to the kidney substance. If too much tension is put on these sutures they cut loose and cause additional hemorrhage.

Thomas Cullen and others have recommended that the kidney be opened by a long, blunt, flat needle which is passed through the kidney from pole to pole and carries a fine silver wire. The kidney is cut with the wire from within outward with a minimum amount of hemorrhage. In kidneys where there is no scar tissue this method is excellent when it is intended to make a long incision in the kidney, but when scar tissue is present the wire will cause more trauma than the knife. It is not always necessary to open the kidney widely. After making a short incision to admit the finger, if it is found that the stone cannot be extracted through it, the incision may be enlarged following the line of Broedel either with the knife, or with a wire suture as suggested by Cullen.

Nephrotomy for abscess is sometimes indicated, though nephrotomy, as a rule, is not satisfactory in tuberculosis of the kidney. If both kidneys are affected with tuberculosis and one is much worse than the other, nephrotomy may be indicated, but sometimes even here nephrectomy gives better results.

F. S. Watson resorts to a double nephrostomy where it is necessary to divert the urine completely from the bladder, either in inoperable malignant growths of the bladder, or as a preliminary to total excision of the bladder. After exposing the kidney it is incised through Broedel's line and a tube is inserted. The ureter is then ligated as close to the pelvis of the kidney as possible. After the fistulous tract into the kidney, which follows the drainage tube, has been well established a receptacle devised by Watson is used. Essentially it consists of a cup shaped funnel that is placed over the fistula and is connected by a rubber tube with a metal receptacle that can be easily emptied.

In most cases of stone where the stone is not very large the operation is best done through the pelvis of the kidney. It is necessary to deliver the kidney into the wound and to expose the posterior surface of the pelvis by turning the kidney forward. The fat over the pelvis is incised

and dissected back on each side. It should not be cut away, as W. J. Mayo has shown that it is very useful in covering the line of sutures and it prevents leakage. Before opening the pelvis the tissues around the kidney are thoroughly protected with gauze in order to prevent soiling of the wound with the escaping urine. After exposing the pelvis it is incised in the general axis of the ureter. The incision should not be carried too close to the kidney substance because large vessels may be injured and it is difficult to suture this region satisfactorily. A suture of fine tanned catgut is placed in each

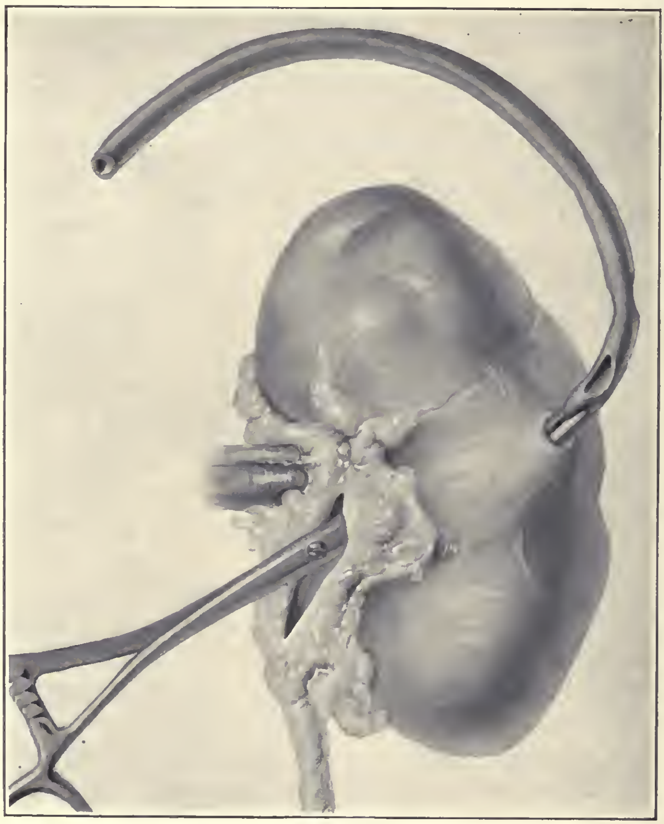

Fig. 592.—The pelvis of the kidney has been opened and a forceps is thrust through to the cortex, where it grasps a soft rubber catheter.

lip of the wound in the pelvis and the ends are left long to act as tractor sutures. The incision is extended until it is large enough to permit exploration of the pelvis and extraction of the stone. The stone is caught with forceps made for that purpose and should be handled gently to prevent crushing it. If fragments are left behind they may form a nucleus for another stone, so it is important to remove the calculus intact. After extracting the stone the pelvis is explored with the little finger if the opening is too small to admit the index finger, but the exploration should be as gentle as pos-

sible because the finger can easily rupture veins about the calices that will cause considerable hemorrhage.

The next step of the operation depends on whether the pelvis of the kidney is to be drained. The great objection to pyclotomy is that if a drainage tube is placed into the pelvis of the kidney the fistula that results is sometimes very slow in closing. Many operators practice suturing the pelvis without drainage when there is no demonstrable infection. As the stone is often the result of infection and is frequently accompanied by infection even though it is mild, it seems that drainage as a rule would be beneficial. This is particularly true since A. J. Crowell, of Charlotte, N. C., has shown that lavage of the kidney pelvis with silver solution carried out for some time after removal of the stone appears to prevent its recurrence. Drainage

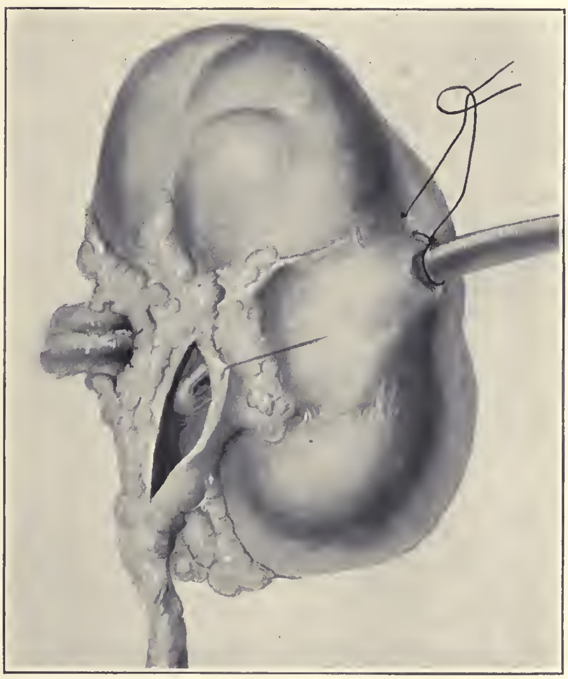

Fig. 593.—The catheter is drawn through so that its tip barely rests in the pelvis of the kidney. The catheter is fastened to the capsule of the kidney with a single stitch.

of the pelvis of the kidney is best provided by inserting a small blunt pedicle forceps through the wound in the pelvis and thrusting it up through the substance of the kidney toward the middle point of Broedel's line, where it is shoved through the cortex. A new soft rubber catheter with one or two additional perforations cut near the end is caught and the tip of the catheter is drawn through into the pelvis of the kidney (Fig. 592). The tip should rest well within the pelvis but not far enough down to occlude the ureter. It is fastened in position by a mattress suture of fine tanned catgut

which passes through the capsule of the kidney and then through the wall of the catheter (Fig. 593). The incision into the pelvis is closed by a continuous suture of fine tanned catgut. The fat and fascia which were dissected from the pelvis are brought together over the suture line and fastened with a few interrupted catgut sutures. The packing is removed and a small cigarette drain is carried down to near the pelvis of the kidney to conduct away any urine if there happens to be leakage. Both the cigarette drain and the catheter are brought out at the upper portion of the wound and the wound is closed in the usual manner. The catheter is connected to a bottle to prevent soiling of the dressing and if there is much infection in the pelvis of the kidney the catheter is kept in position three or four weeks and after a few days installations of silver solution are made into the pelvis. In this manner we have the advantage of the incision through the pelvis, together with drainage of the pelvis, but without the prospect of a prolonged fistula which may occur if the drainage is inserted into the wound in the pelvis. At the same time the catheter introduced in the manner indicated causes almost no destruction of the renal parenchyma and only a very small amount of bleeding. Usually there is no leakage around the catheter and the wound can be kept dry.

Aside from the extraction of stones pyelotomy is but seldom indicated. Occasionally pyelitis demands drainage in this manner, but as a rule the urologist can treat pyelitis satisfactorily by catheterizing the ureters and lavage of the pelvis. The beneficial action of catheterization of the ureters may be due to the dilatation of the ureter which makes better drainage from the pelvis. Hunner, of Baltimore, has obtained satisfactory results in many types of obscure pain merely by dilating strictures of the ureter.

Hydronephrosis was formerly treated by plastic operations. Various operations have been devised for the infolding of the hydronephrotic sac or for the removal of a valve or a lateral anastomosis of the ureter to the lower portion of the hydronephrotic sac. These operations have been on the whole disappointing. Occasionally the hydronephrotic sac may be drawn up onto the kidney around its whole circumference and stitched to the capsule of the kidney. The kidney is thus invaginated into the sac. This procedure, which is recommended by C. H. Mayo, lessens the cavity of the hydronephrotic sac and tends to straighten kinks and folds. Even here, however, recurrence of the hydronephrosis occurs. Sometimes hydronephrosis is due to plugging of the ureter with a stone or to a kink from adhesions, or from a low artery of the kidney which produces a fold in the ureter just after the ureter leaves the pelvis of the kidney. Obviously, such obstructions must be removed and if a stricture is found it may sometimes be corrected by incising the stricture longitudinally and suturing the wound transversely to the axis of the incision, which is a common principle in plastic surgery. The excision of so-called valves is usually unsuccessful in producing a cure. If there is no obstruction that can be demonstrated and if the opposite kidney is sound nephrectomy offers the best solution of the problem.

THE URETER

Operations upon the ureter consist in incising a stricture, in delivery of a stone, in suturing a wound in the ureter, in uniting the ureter when divided, or in transplanting it.

A stricture of the ureter is best treated by gradual dilatation if it can be entered by a bougie or catheter. If the stricture is in the lower end of the ureter just as it enters the bladder and it is impossible to pass a bougie or catheter, the ureter is exposed and incised about the brim of the pelvis. This may usually be done through a muscle splitting incision. An attempt is made to pass a sound or bougie from above downward and if this is impossible a stout probe is introduced to the stricture which lies close to the bladder. The bladder is then opened by a suprapubic cystotomy and, with the finger in the bladder, the probe is gradually shoved through into the bladder and out at the suprapubic wound. Two stout linen or silk threads are tied to the end of the probe and the probe is withdrawn, pulling the threads along with it. Both

Fig. 594.—A stricture of the lower end of the ureter. A communication has been established with the bladder by the method described in the text, and a large silver wire or a ureteral catheter is drawn through.

of these threads are long and the ends of one of them are tied together. The other serves as a guide to carry through either a large silver wire or a ureteral catheter, which is passed from the wound in the ureter downward through the bladder. If desired, a larger catheter can be passed after a few days. On account of the possibility of sepsis a stout silver wire probably does as well as the catheter and is less likely to produce infection. The wound in the ureter is drained by a cigarette drain which comes out at the abdominal wound (Fig. 594). If a ureteral catheter is used it should not

be permitted to stay in place more than a week and is then succeeded by a silver wire for the rest of the period of drainage. After two or three days the catheter or wire is gently sawed back and forth to widen the tract. This produces a large fistula between the ureter and the bladder slightly to the distal side of the stricture. Of course, the stricture must be in a location where the ureter either enters the bladder wall or is in juxtaposition to the bladder.

In operations for stone in the ureter the stone is localized by roentgen rays, the ureteral catheter, or both, and an incision is made at a point where the stone will be most accessible. Frequently the stone is found in the ureter just as it crosses the brim of the pelvis or further down just as it enters the bladder, as these are points of natural constriction of the caliber of the ureter. The incision may be made as a muscle-splitting incision as in the McBurney operation for appendicitis, only the muscles are split more widely than in the appendicitis operation. When the peritoneum is reached it is not incised but is stripped up. This is readily done with dry gauze on a sponge forceps, the stripping being toward the midline. A long retractor is inserted toward the midline and the iliac arteries are demonstrated. The ureter practically always adhers to the peritoneum and is recognized as a band. If a good light is obtainable and the ureter can be watched for a moment peristalsis will often be seen. The ureter may be dilated above the stone. The stone can frequently be felt and the ureter thereby is readily recognized, When the peritoneum has been stripped up as far toward the spine as can be readily done the ureter will be found adherent to the peritoneum and just external to the line of attachment of the peritoneum to the spine. If the pelvic portion of the ureter is to be exposed an incision along the outer border of the rectus muscle is made, or a lower muscle-splitting incision. A useful guide to the ureter is the point at which it crosses the iliac artery at the bifurcation of the common iliac.

After the stone is located the ureter is isolated by blunt hooks or by passing a stout catgut ligature around it without tying the ligature. The ureter is brought toward the wound. It should not be dissected any freer from the surrounding tissues than is necessary because this may interfere with its nutrition and consequently delay healing. After protecting the surrounding tissues with gauze packing a longitudinal incision is made over the stone which is extracted. It is best, as a rule, not to attempt to suture the ureter, though if the incision is unusually long a few interrupted sutures of fine tanned or chromic catgut may be placed. They should not penetrate the whole thickness of the ureteral wall. A cigarette drain or a strip of rubber tissue is carried down to the wound in the ureter. If the wound in the ureter is in the pelvis a soft rubber tube should never be used for drainage. Several cases are on record where the resting of a soft rubber tube on the iliac artery unprotected by peritoneal covering has produced secondary hemorrhage by pressure necrosis in the artery. A cigarette drain or a strip of rubber tissue will hardly cause this. In extraction of a stone from

the ureter above the pelvis, where the drainage will not be in contact with any large vessels, a soft rubber tube may be used.

Many ureteral stones can be removed with a cystoscope in the hands of an expert urologist. If this seems possible after the size and location of the stone have been determined, an effort should be made to extract the stone in this manner before resorting to operation. Only one well trained in such work should attempt this, however, as it requires much skill and practice.

The ureter is sometimes divided accidentally in operations in its neighborhood, particularly in extensive operations for malignant growths of the uterus. If the other kidney is sound the Mayos practice simple ligation of the ureter and find that the kidney is obliterated with but little or no pain and that the other kidney takes up the work satisfactorily. If, however, there is any suspicion of the function of the opposite kidney, this should not be done. If it is possible to do so without too great risk to the patient an effort should be made to reestablish the continuity of the ureter. Various operations have been devised for this purpose, but it has been quite clearly proved, particularly by the work of R. J. Payne, of Norfolk, Va., that all of the methods of uniting a divided ureter are likely to be followed by stricture except the simple end-to-end method. This is logical because here the minimum amount of raw surface is apposed and consequently there is less scar tissue to cause later contraction.

If a satisfactory exposure can be had the suturing together of a divided ureter is not a very difficult procedure. The sutures may be of very fine silk or preferably of fine tanned or chromic catgut. The objection to silk is that it may work into the lumen and as a foreign body form a nucleus for a stone. Three interrupted sutures are passed at equal distances around the circumference of the ureter and approximate the divided ends of the ureter in much the same manner as Carrel uses in suturing blood vessels. All of these sutures should be passed before any of them is tied. In this manner they can be simultaneously drawn taut and tied one at a time while the others are held taut, so keeping unnecessary strain from the suture that is being tied. The ends of the sutures are left long, the margins of the wound are whipped over with a continuous suture of fine tanned or chromic catgut in a fine curved needle while holding the three tractor sutures in such a manner as to render the part of the wound that is being sutured readily accessible and moderately tense. While suturing between two tractor sutures the third should be slightly pulled away to prevent the possibility of catching the opposite wall of the ureter in the sutures. The sutures should not be drawn too tightly, but just enough to secure accurate approximation. After the whole circumference of the divided ureter has been sutured, the ends of the tractor sutures are cut rather long and the ureter is returned to its bed.

When a considerable portion of the ureter has been sacrificed it is impossible to approximate the ends of the ureter without too much tension. As suggested by Payne, of Norfolk, much can often be gained by mobilizing the kidney and its pelvis and the upper ureter through an incision

made as though a nephrectomy were to be done. The kidney and ureter may be shoved down to such an extent as to overcome a considerable defect in the ureter and permit approximation of its ends which would otherwise be impossible.

In a contemplated excision of the bladder or in injury of the ureter near the bladder a direct anastomosis cannot be made and here the question of the disposition of the ureter must be settled. There is a choice of four different methods.

1. The ureter may be tied and, as has already been mentioned the kidney will, as a rule, eventually atrophy and give no further trouble. This method may be used in emergencies when the patient is in shock or the condition is so grave as to demand the quickest procedure and when there is assurance that the ureter and kidney on the other side are normal. Such a method should be only exceptionally resorted to as the aim in surgery should be, first, to preserve life and, second, to preserve function. It is only when these two aims are in conflict that function should be destroyed.

2. The ureter may be transplanted to the skin as originally proposed by Harrison and by Bottomley.[1] Here the ureter is brought to the skin of the loin and a special apparatus used to collect the urine. This transplantation can be done either extraperitoneally or transperitoneally, transplanting preferably one ureter at a time. Instead of doing this the ureter may be ligated and a nephrostomy done according to the method of Watson, using a special apparatus to collect the urine from the nephrostomy wound. Such procedures may be resorted to in patients that are past forty years where both ureters must be transplanted.

3. The ureter may be transplanted into the bowel. This may be necessary because of the extensive disease of the bladder or in exstrophy of the bladder.

4. The ureter may be transplanted into the bladder. This, of course, is the most desirable disposition of the ureter but unfortunately it is not always possible. In resection of a portion of the bladder for malignant disease when the orifice of the ureter is involved, the ureter may be transplanted into the bladder with considerable assurance of a permanent preservation of the function of the kidney from which the ureter comes.

The technic of this transplantation depends to some extent upon the amount of bladder that must be removed. The Coffey operation should be used wherever possible in order to prevent back pressure from the bladder and to establish a valve of the mucosa. This operation consists in making an incision about an inch long through the serous and muscular coats of the bladder and down to the mucosa. After undermining the muscular coat on each side a small stab wound is made through the mucosa at the distal end of the incision. The ureter is split and caught near the tip with a single suture of plain catgut which has a needle on both ends. First one needle and then the other is passed through the stab wound in the mucosa and

[1]Jour. Am. Med. Assn., 1907, xlix, 141, et seq.

penetrates the bladder from within outward at a point about three-quarters of an inch from the stab wound. There should be a short space between the points of exit of the needles. The suture is then gradually pulled upon until the ureter is drawn into the bladder. The ureter is fixed by tying this suture and the muscular and peritoneal coats of the bladder are sutured together over it. An additional stay suture of catgut fixes the ureter to the bladder wall about a quarter of an inch from the site of the anastomosis. If it is possible to do so it is best to place a second row of sutures to bury the first row, though care must be taken not to constrict the ureter, as this will have the effect of damming back the urine and may produce a hydronephrosis with destruction of the kidney, just as would occur after ligation of the ureter. The ureter should be handled as gently as possible during all of these manipulations. It should never be clamped at the end or elsewhere even with a soft nose forceps and its mucosa should not be sutured except with the first fixation suture which is of catgut and passes through the tip of the ureter, fixing the end of the ureter within the lumen of the bladder. The next fixation suture which is passed about one-quarter of an inch from the site of anastomosis does not penetrate to the mucosa of the ureter.

Frequently, however, such an ideal technic cannot be carried out and it may be necessary to make a direct transplantation. Whenever a transplantation is done there should be no tension at the junction of the ureter and bladder for this will surely invite failure. If so much of the bladder and ureter are sacrificed, as after an operation for cancer, that it is impossible to implant the ureter after the method described without tension, the direct implantation should be done. Here the inch of the ureter that is imbedded in the bladder wall is not needed so tension may be avoided. In any instance, no more of the ureter should be separated from its bed than is necessary for the manipulation because an extensive dissection will destroy the blood supply of the ureter and predispose to fistula formation or to poor healing.

In direct transplantation, after mobilizing the ureter and cutting its end either obliquely or splitting it, a single mattress suture of linen is passed through the tip of the ureter and left long. A uterine probe is introduced through the urethra, either in man or woman, and the tip of the probe is pushed into the wall of the bladder at a point where there will be least tension between a transplanted ureter and the bladder wall. A short stab incision is made over the point of the uterine probe and the long ends of the linen suture in the ureter are fixed in a loop knot around the end of the uterine probe (Fig. 595). The probe is then withdrawn, leaving the suture protruding from the the external urethral meatus. A catgut suture is passed through part of the wall of the ureter about one-half an inch from its end. The linen tractor suture is pulled upon until the ureter is drawn into the bladder and the catgut suture is flush with the external surface of the bladder wall, when the catgut suture takes a bite in the bladder and is tied. A similar suture

is inserted on the opposite side of the ureter, catching only the muscular coat, and further fixes the ureter to the bladder wall. Several other sutures are placed still further to invaginate the ureter. If it is possible to do so the ureter is best implanted into a portion of the bladder that is covered with peritoneum, or sometimes a strip of peritoneum can be left on the anterior surface of the ureter which will greatly facilitate the healing. Slight traction is made on the linen tractor suture to determine accurately the amount of tension that will

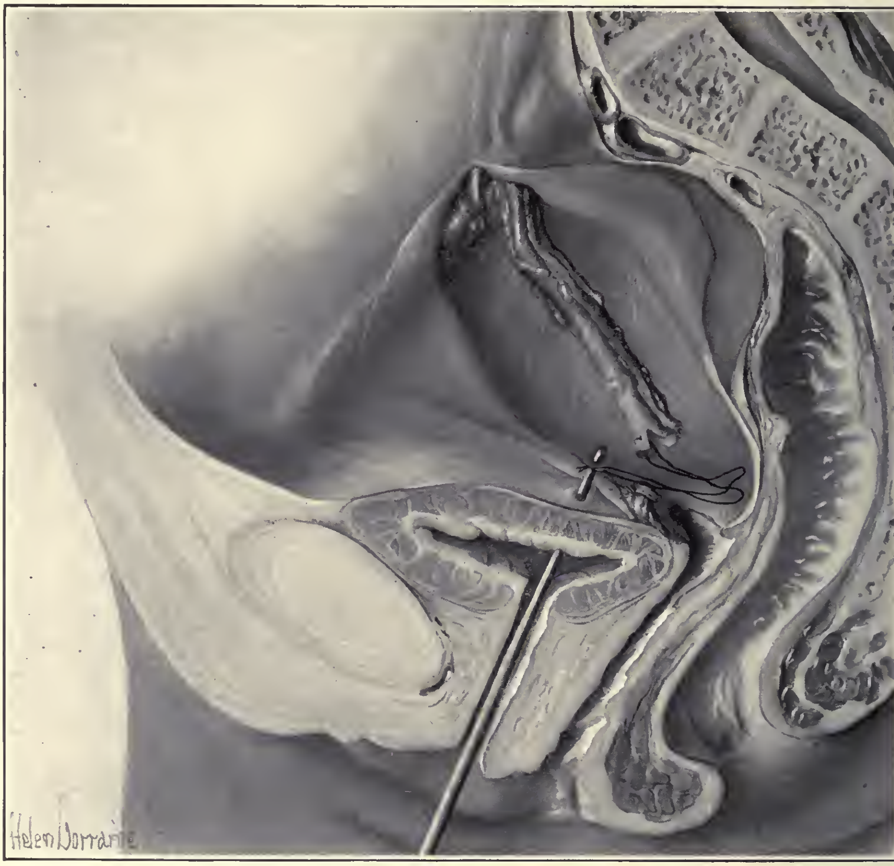

Fig. 595.—A method of transplanting the ureter. A probe has been thrust through the bladder wall and the suture on the end of the prepared ureter is fastened to the tip of the probe.

be needed to keep the ureter in position. When this is established the tractor suture is fastened to the vulva in the female or attached to a thin rubber band and fastened to the leg of the patient in a male (Fig. 596). If too much traction is used the suture quickly cuts out and if too little is made there is not sufficient relief of whatever tension exists between the ureter and bladder at the point of junction. Therefore, it is important to determine this point when the anastomosis has been finished and before the wound is closed. The dissected portion of the ureter is covered with a peritoneal flap (Fig. 596) or with the sigmoid. A small

piece of rubber dam is carried down to the site of the anastomosis to conduct away any urine if there is leakage. All sutures that involve the bladder mucosa should be of plain catgut and others in the bladder wall may be of fine tanned or chromic catgut. The tractor suture of linen will come away in five or six days and in this time union will be sufficiently firm for no leakage to occur, particularly if peritoneum can be utilized either on the anterior surface of the ureter or on the bladder wall. The bladder is drained either by an indwelling catheter in the female, or by a perineal or suprapubic cystotomy in the male.

Fig. 596.—The ureter has been drawn into the bladder by the method shown in the preceding illustration. The peritoneum has been dissected so as to form a flap and completely envelops the ureter.

It may be necessary to transplant both ureters into the bowel in exstrophy of the bladder or where a malignant growth involves so much of the bladder wall as to render a radical operation impossible or to necessitate removal of the whole bladder. In exstrophy of the bladder, the operation should not be done until the child is about four years old when he can attend to the

emptying of the bowels at sufficient intervals to prevent too great an accumulation of urine in the colon. In operation for exstrophy many plastic procedures have been advised, such as turning in skin flaps from the margin of the ectopic bladder and reconstructing a urethra. Such operations, even if successful, do not give control of the urine, which is the most desirable thing to be attained. Besides, turning in flaps from the margins of the bladder necessitates the turning in of some portion of the skin in which hair will later form, and this becomes a perpetual source of inflammation and a nucleus for stone formation.

Plastic operations for exstrophy of the bladder, then, seem to accomplish very little. The operation of Maydl consisted of dissecting out that portion of the base of the bladder containing the ureters and transplanting this segment into the rectum as a transperitoneal operation. In this manner the natural valves of the ureters are preserved but the terminal nerve supply is, of course, destroyed. Moynihan has slightly modified the Maydl operation by taking a large portion of the bladder. Operations after the Maydl principle have been followed by a large mortality. The injury to the nerve supply of the lower portion of the ureters and the necessarily poor blood supply to the transplanted segment of bladder which, of course, demands more blood the larger the segment that is transplanted, are probably responsible for the unsatisfactory results. Then, too, the transplantation of both ureters at the same operation greatly increases the danger. As pointed out by C. H. Mayo a considerable portion of the urine is carried to the right side of the colon as after the Murphy drip and is here absorbed. If both ureters are transplanted at the same time uremia may result, but if there is an interval of two weeks or more between the transplantations, the patient will have developed sufficient protective reaction against the unphysiologic disposition of the urine to withstand the result of the second transplantation. This is shown by the fact that C. H. Mayo[2] reports that since 1896 six patients with exstrophy of the bladder have been operated upon by plastic methods and none has control of the urine; three were operated upon by the Maydl-Moynihan method and two of these died in the hospital from uremia; while thirteen patients were successfully operated upon by the transplantation of the ureters with only one operative death. These statistics point clearly to the wisdom of transplantation of the ureter into the sigmoid at separate sittings as the operation of choice in exstrophy of the bladder. Exactly the same technic, of course, could be used when malignant disease of the bladder is so extensive as to necessitate the transplantation of the ureters elsewhere, though with the difference that in the young the transplantation into the sigmoid is the most satisfactory method, whereas in the elderly it may be safer to bring the opening of the ureters to the skin in the loin as practiced by Bottomley or to use the double nephrostomy of Watson. The indica-

[2]Mayo, C. H.: Jour. Am. Med. Assn., 1917, lxix, 2079, et seq.

tions for the different procedures depend to some extent upon the desire of the patient.

If the ureter is to be transplanted into the sigmoid either for exstrophy of the bladder or for malignancy, the first operation is best done on the right side, making an incision slightly to the right of the midline, because the sigmoid is on the left and, as pointed out by C. H. Mayo, if the operation on the left side is first done it may be more difficult to mobilize the sigmoid in the second operation which must be on the right side. After exposing the sigmoid and determining the point at which the anastomosis should be made, and particularly with regard to a subsequent operation on the left side, this point is fixed by clamping the sigmoid with a large curved intestinal clamp. The lower end of the ureter is dissected out and divided close to the bladder and the proximal end is split for a quarter of an inch. In order to preserve the nutrition of the ureter, as in operations for transplantation of the ureter into the bladder, no more of the ureter is dissected free than is necessary for the purposes of the operation. The distal end of the ureter is tied and in exstrophy it may be buried in the tissues around it by a few catgut sutures. The peritoneum and muscular coats of that portion of the sigmoid in the grasp of the curved intestinal clamp is incised for about an inch and a half. It is best to make this incision through the firm longitudinal bands in the wall of the sigmoid. The incision is carried down to the mucosa but not through it. At the distal portion of the incision the mucosa is punctured and a fine tanned catgut suture which transfixes the tip of the ureter is threaded with a needle at each end, carried through this punctured wound in the mucosa, and penetrates the bowel half an inch distal to the punctured wound. Both needles are carried through a short distance from each other and the suture is tied, so fixing the ureter in its new position. The wall of the ureter is caught in the bite of a catgut suture just as it penetrates the mucosa and the suture also catches a bite in the muscular and peritoneal coats of the sigmoid on each side. This suture is tied so as still further to fix the ureter in the wall of the sigmoid. The incision is closed by continuous sutures of tanned or chromic catgut which bury the ureter on the mucosa. A valve is formed of the mucosa which prevents back pressure. This method of Coffey tends greatly to diminish ascending infection of the kidney. By using this principle of his, pressure within the bowel produces a valve-like effect on the mucosa and occludes the end of the ureter against the gas pressure within the bowel, but at the same time does not produce sufficient pressure to prevent delivery of the urine into the bowel. The wound is closed without drainage, or else with a small soft tube of rubber dam. The sphincter is dilated and a tube inserted a few inches in the rectum for the first four or five days in order to facilitate the emptying of the urine until the bowel gradually becomes accustomed to it. The second ureter is transplanted about two weeks later if the patient is in good condition.

THE BLADDER

Tumors of the bladder may require operation. Many tumors, particularly the benign papillomas, are cured by fulguration, and radium in some cases is beneficial. If the tumor is malignant and involves a considerable portion of the bladder wall, and particularly if it does not readily respond to fulguration or radium, operation is the best method of treatment. If the growth has a distinct pedicle the mucosa can be excised around the pedicle with a cautery but usually the resection should include the whole thickness of the bladder wall, going some distance beyond the apparent margins of the growth into what seems to be healthy tissue. Excision of the total thickness of the bladder wall is no more difficult than excision of a portion of the wall and is more likely to result in cure. If the growth involves the part of the bladder that is covered with peritoneum the peritoneal cavity is opened and packed off and the diseased section is removed. If, however, other portions of the bladder are involved, the operation should be done extraperitoneally if possible. Most tumors of the bladder originate in the base of the bladder and many of these involve one of the ureteral openings, so that excision of this section of the bladder will involve transplantation of the ureter, or else ligation of the ureter if the remaining kidney is healthy and it is impossible to transplant the ureter. Occasionally, both ureters require transplantation.

Whether the peritoneal cavity is opened or not the patient is placed in the Trendelenburg position and good exposure is obtained by a large incision in the bladder. Care is always taken to protect the prevesical space by packing it with gauze. The incision is preferably made transversely, though the location of the disease will control its direction. The excision of the bladder wall is made with an electric cautery wherever possible. The bladder wound is closed with two layers of catgut sutures, the inner layer of plain catgut and catching as little as possible of the mucosa. The outer layer of tanned or chromic catgut is inserted through the muscular coat only and like the inner layer is a continuous suture. Drainage is always placed either through a portion of the incision, preferably as close to the peritoneal fold as possible, or the incision may be closed completely and drainage instituted through a stab wound at about the apex of the bladder and an inch or more from the sutured incision. If it is necessary to dissect the space of Retzius extensively, a gauze cigarette drain is placed to the bottom of this space in addition to the drainage in the bladder.

Diverticula of the bladder are treated satisfactorily by operation. The diverticulum should be accurately located by roentgen rays and by cystoscopic examination before the operation is attempted. The bladder is opened suprapubically and the diverticulum explored with the finger and by inspection with the patient in the Trendelenburg position. If the pouch is not very adherent it may be pulled into the bladder with forceps, or, using the technic of H. H. Young, it may be everted by a suction apparatus that is attached

to a large tube which is placed over the neck of the diverticulum. Small non-adherent diverticula are treated satisfactorily in this way. When the diverticulum is large or when it is adherent it is necessary to dissect it externally. After opening the bladder widely through the prevesical space and protecting the prevesical space with gauze packing, the diverticulum is explored with the finger. It may be packed with gauze to identify it, as suggested by Lower, or with one or two fingers in the diverticulum, as practiced by Judd, dissection is carried through the prevesical tissues to the sac which is lifted up by the fingers within it. If the sac is covered by peritoneum the peritoneum may be opened though usually this is not necessary. The vas deferens and the ureter must be identified and injury to these structures avoided. Occasionally the ureter is involved in the diverticulum and it may be necessary to divide it and reimplant it into the bladder. If the prostate is enlarged it should be removed at the same operation. When the sac has been completely freed the internal relation of the neck of the sac to the ureter is noted and the diverticulum is then cut away. The opening in the bladder is closed as after operations for tumors. The suprapubic opening is sutured except for a drainage tube which comes out at the upper part of the bladder wound near the peritoneal fold. A cigarette drain is carried down through the prevesical space to the site of the old diverticulum.

Approach to the bladder for the operations that have been mentioned, or for stone or for drainage is frequently indicated. This operation of suprapubic cystotomy may be exceedingly simple when the bladder is distended or capable of being distended, or it may be difficult if the bladder is thick and contracted. Where it is possible to do so it is best to distend the bladder with some mild antiseptic solution, such as boric acid solution, just before the operation. A soft rubber catheter is inserted into the bladder and the warm boric acid solution is gradually introduced by gravity until the bladder is filled. If the irrigating can is not more than two feet above the level of the patient's body it is hardly possible for the bladder to be damaged by the irrigation. The catheter is left in position. The bladder should never be filled by a piston syringe, as several cases are recorded in which an apparently low degree of pressure with such a syringe ruptured the bladder. If gravity is used slowly and carefully such an accident is impossible. It must be borne in mind, however, that in manipulating a well filled bladder strong pressure upon it may cause it to rupture. A tape is tied around the penis in order to prevent the escape of the fluid around the catheter. An incision is made in the abdominal wall, usually a longitudinal incision, and after separating the fibers of the recti and pyramidalis muscles the fascia immediately beneath them is incised and the prevesical fat exposed. The peritoneal fold in the upper portion of the wound is recognized and gently stripped upward with gauze. If it is opened it may be immediately sutured without danger. The fat is divided down to the anterior wall of the bladder and is then pushed to the side and downward into the space of Retzius. It is well to place a small gauze pack at the

upper angle of the wound in order to protect the peritoneal cavity from being accidentally opened while enlarging the incision. If the operation is done merely for drainage and exploration a short vertical incision that will admit the finger is all that is necessary, but if a large tumor is to be removed a more ample exposure is required. Here the incision in the bladder wall should be transverse, keeping along its apex and as close to the peritoneal fold as seems safe. If it goes down into the space of Retzius and near the urethral opening it is difficult to suture and to heal. The bladder wall having been recognized may be fixed either by two Allis forceps or by two sutures of catgut or silk that are inserted with a round curved needle. The fluid is then drawn off through the catheter in the urethra and the bladder is incised between the two forceps or sutures. In this way the prevesical tissues are not flooded with the vesical contents and infection is less likely to occur. Where the bladder is distended from an impermeable obstruction, the urine may be drawn off by thrusting a trocar and cannula through the bladder wall which is incised after withdrawing the trocar and cannula. It may occasionally be difficult to recognize the bladder wall if not distended, but when filled with fluid it is easily identified. After opening the bladder the incision is extended for better exposure or the stone is extracted, or drainage instituted, according to the indications. The bladder should always be explored thoroughly with the finger before drainage is placed. If the incision in the bladder wall is short a drainage tube is brought out at the upper portion of the incision and the lower margin of the wound is closed with catgut sutures. These sutures in a short wound are interrupted, of tanned catgut, and take either none of the mucosa or as small an amount of it as possible. In a larger bladder wound the two layers of sutures that have been mentioned are the best method of closing the wound. Bleeding in the bladder wound is controlled by whipping over the bleeding spot with small plain catgut in a round noncutting needle.

Occasionally, drainage is done through the perineum and the suprapubic wound is closed entirely. With the patient in the dorsal position pedicle forceps or long dressing forceps are inserted into the bladder and through the internal meatus into the urethra. Pressure is made on the forceps so that the tip bulges in the perineum and is cut down upon in the perineum. A rubber drainage tube or a large soft rubber catheter is grasped with the forceps, drawn through into the bladder, and fixed to the skin of the perineum with a silkworm-gut suture. The end of the catheter should not be more than two inches within the bladder as otherwise it will cause an unnecessary amount of irritation. The suprapubic wound in the bladder may then be entirely closed.

If a suprapubic cystotomy is done with the bladder collapsed the abdominal incision is the same as when the bladder is distended, but the vesical wall is much more inaccessible. Having the patient in the Trendelenburg position is a great help. Dissection is carried down to the pubic bone and then the prevesical fat is cut through until the bladder is demonstrated. After it has been recognized it is incised and the operation finished in

the usual manner. If a sound or a catheter can be introduced into the bladder usually it can be distended, but careful dissection without a sound will, as a rule, expose the bladder wall without much difficulty.

With an impermeable stricture or a prostatic obstruction it is sometimes impossible to enter the bladder with an instrument through the urethra. These patients are often poor surgical risks and it is necessary to evacuate the urine by as simple a process as possible. Here a puncture with a trocar and cannula is satisfactory. A trocar and cannula are selected so that the trocar can be removed and a small soft rubber catheter threaded through the cannula into the bladder. The trocar and cannula should be of such a type that the urine can be drawn off through a lateral projection near the end of the cannula. Before the operation the catheter is tested to see that it will go through the cannula easily. The skin of the abdomen is infiltrated and an incision of half an inch is made just above the pubis and close to the pubic bone. The deeper tissues are infiltrated with procaine solution, a proper trocar and cannula are grasped firmly, and thrust quickly into the bladder in a direction inward and upward. Of course this is never done except when the bladder is fully distended. If the trocar and cannula go straight inward the prevesical space may be injured, the trocar will sometimes cut the bladder wall obliquely and if there is a large prostate it may not enter the bladder at all. By directing the thrust upward as well as inward this accident to the prevesical space is avoided and there is no danger of injuring the peritoneum if the bladder is distended, provided the entrance point in the abdominal wall is just above the pubic bone. The trocar is pulled back and the urine allowed to flow. After the bladder has been emptied the trocar is unscrewed, the cannula being left in position. The cannula must be kept well within the bladder wall, because if it is once withdrawn after the bladder has been emptied it will not only be impossible to reinsert it but leakage will certainly occur into the prevesical space. The previously selected soft rubber catheter with an additional eye cut near the end is threaded through the cannula which is then withdrawn.

The amount of catheter to be left in the bladder is determined by comparing it with another catheter of equal length. There should be four inches of it below the level of the skin and if the patient is stout five inches would be better. It is wrapped around with adhesive at the skin level and fastened in position by a suture of silkworm-gut which goes through the skin and through the adhesive that is wrapped around the catheter but does not penetrate the wall of the catheter itself. The catheter should be new and should be tested before it is used. An old one will sometimes break and may leave a portion of it in the bladder.

This method of drainage will not cause leakage around the catheter and the patient can be kept perfectly dry. The catheter must not be removed, however, for at least two weeks unless as a preliminary step to an operation, because it takes about this time for the granulations to produce firm tissue around its wall and so prevent infiltration of urine into the prevesical

space. If the catheter has become accidentally displaced in the first few days after such an operation and cannot be readily reintroduced, a suprapubic cystotomy should be done at once to protect the prevesical space from infiltration of urine.

Total excision of the bladder may sometimes be indicated. The first stage consists of an anastomosis of the ureters to the sigmoid, or bringing them to the skin of the groin, or establishing the bilateral nephrostomy of Watson. Some weeks after this has been done the bladder is excised as though it were a cystic tumor. The anterior surface of the bladder is exposed through an ample incision and separated from the peritoneum anteriorly and laterally. It is gradually delivered into the wound and the dissection continued until the neck of the bladder, the inferior vesical arteries, and the stumps of the ureters have been reached. The vessels are doubly clamped and the base of the bladder is separated from the rectum as far as possible. The neck of the bladder is divided, preferably with the cautery, while making traction to pull up as much of the urethra as possible. Such an operation is rarely indicated.

Perineal section is not done as frequently as in preantiseptic days, but is occasionally indicated particularly for deep stricture. If a grooved sound can be passed into the bladder the patient is placed in the dorsal position and an incision is made in the perineum just back of the scrotum down to the urethra, which is opened. This incision can be carried to an inch of the anus if kept in the midline. The urethral bulb must not be injured and is pulled forward in the midline so that the urethra is opened on the grooved staff and freely incised to the apex of the prostate. The staff is removed and a grooved director or Teale's gorget, is inserted and the finger is pushed into the bladder with a boring motion along the director or gorget. A drainage tube is inserted. A soft rubber rectal tube does well for this purpose. It should be so placed as not to project into the bladder more than an inch. It is fixed in position by suturing it to the skin with an interrupted silkworm-gut stitch. Bleeding is controlled by whipping over the bleeding points with catgut in a needle before inserting the drainage tube and by iodoform gauze packing around the tube down to the urethra. If there is but little infection in the bladder and the operation is done for stone or for exploratory purposes, the tube may be removed in three days. In cystitis, drainage must be kept up for several weeks. When necessary to gain greater room the incision may be continued into the prostatic portion of the urethra along the midline.

When it is impossible to introduce a sound or staff into the bladder, external urethrotomy becomes more difficult. A sound is introduced down to the point of obstruction, which is usually in the membranous urethra. The incision is carefully carried down to the sound and the bleeding is controlled by clamping or by whipping over the bleeding points with plain catgut. The urethra is incised as far as the obstruction. Sometimes a view of the stricture can be obtained and a probe or bougie accurately introduced through the

stricture. If a sharp-pointed hemostat can be introduced the jaws are spread apart and the stricture is dilated. A pair of larger forceps is then inserted and the jaws are spread. When the stricture is very dense or when there is a considerable amount of inflammation it may be divided by an incision with a knife. Very dense strictures have been excised and efforts have been made to approximate the ends of the urethra. This, however, is tedious and recurrence is frequent, though where there is a local heavy deposit of scar tissue excision may be attempted.

If the opening in the stricture cannot be inspected a filiform bougie is introduced through the urethral wound. This will serve as a guide for the introduction of a large instrument or a pair of sharp nose forceps, or a knife to divide the stricture. The stricture is thoroughly divided so that the finger can be introduced into the bladder. A large soft rubber catheter or a small rectal tube is carried into the bladder and held in position by suturing it to the skin. This should be removed in three or four days, the tube boiled, and reinserted. The wound is irrigated several times a day with hot boric acid solution. The patient is given hexamethylenamin if the kidneys are in a condition to stand it without too much irritation and every effort is made to prevent infection.

Occasionally after a rupture of the urethra it is impossible to enter the bladder from below. Here a small suprapubic incision is made and the urethra catheterized or a sound introduced into the urethra from within the bladder. This will demonstrate the location of the urethra in the perineal wound and is a much safer procedure than a prolonged blind dissection in the perineum.

CHAPTER XXIX

OPERATIONS ON THE PROSTATE GLAND, THE TESTICLES AND THE PENIS

Prostatectomy may be done by the perineal or the suprapubic route. There are ardent advocates of both routes though the suprapubic has become more popular. The operation of H. H. Young is probably the most satisfactory for removal of the prostate through the perineum. The suprapubic method is simpler and the enucleation following the general principles of the technic of Squiers has given excellent results.

The operator should have the technic of either route at his command. In the small fibrous prostate, especially if there is a possibility of malignancy, the perineal route is preferable. In the large adenomatous prostate, removal by the suprapubic route seems better. The objections to the perineal route are:

1. It is more complicated and the operation takes somewhat longer to perform.
2. There is a possibility of injury to the rectum and fistula formation.
3. It is somewhat more difficult to control the bleeding by the perineal route.
4. Persistent urinary fistula is probably more frequent by the perineal route.

The objections to the suprapubic route are:

1. The removal of the whole urethra contained in the prostate is sometimes followed by stricture.
2. If the prostate is cancerous and very adherent it can be removed more satisfactorily by sharp dissection through the perineal route than through the suprapubic.
3. It is claimed by some operators that on account of the extensive manipulation within the bladder by the suprapubic route uremia is more likely to result.

The choice of these two routes depends somewhat upon the experience of the surgeon. The operation, particularly the suprapubic operation, is technically not very difficult, though it is particularly necessary to have had training in assisting and observing these operations done by one who is skilled in this work before the surgeon attempts the operation.

It is most important to have the patient in the proper condition to stand the operation. The high mortality for prostatectomy in the early history of this operation was partly due to a crude technic but more to the inability to determine the functional capacity of the kidneys. When there is much

residual urine the back pressure upon the kidneys gradually alters the conditions under which they function and they gradually meet these changed conditions. A sudden and permanent removal of this back pressure may affect the kidneys profoundly. For this reason the patient should either be catheterized or drained for some days or for some weeks before a prostatectomy is done. The renal function should be accurately determined, partly by chemical analysis of the urine, but chiefly by functional tests of the kidneys. As pointed out forcibly by Louis Frank,[1] not only should the function of the kidneys be determined by the phenolsulphonephthalein secretion, but by the estimate of the blood urea, and if greater accuracy is demanded by the determination of Ambard's coefficient. No matter how skillful the operative technic may be, if these patients do not show satisfactory renal function, disaster is likely to follow. If in doubt, it is wise to drain, either by an indwelling catheter or by a suprapubic drainage, until such a time as the blood urea shows that the kidneys are working satisfactorily.

Suprapubic prostatectomy with enucleation of the prostate according to the method of Squier gives very satisfactory results in most cases. Before the operation is begun a large soft rubber catheter is introduced through the penis and left in position. This catheter should be new so that it will not break. The bladder is exposed suprapubically, as in suprapubic cystotomy. If there has been suprapubic drainage the incision is made from the drainage tract to the pubis. The attachments of the bladder above the drainage tract to the peritoneum are not disturbed. If an effort is made to enter the bladder simply by dilating the old drainage tract, the peritoneum, being the loosest attachment, may be torn. If suprapubic drainage has not been previously established the prevesical space should be protected by gauze packing before the bladder is opened. After opening the bladder the index finger of the right hand is inserted into the internal meatus and enucleation is begun by breaking through the prostatic urethra with the finger near the roof of the urethra and a little to the right side. It is best to enucleate the prostate with the ungloved hand. The gloved left index finger may be inserted into the rectum and the prostate pushed up, which though not necessary, will aid materially in the manipulation (Fig. 597). If the prostate is densely adherent and there is no definite line of cleavage it is probably cancerous and operation by the suprapubic route should be abandoned. The patient is then drained and a radical operation for cancer of the prostate undertaken by the perineal route several days later, unless the disease had progressed to such an extent that the cancer is inoperable. If the prostate separates fairly easily the finger is swept down on its side, keeping close to it, and loosening it from the apex of the gland backward (Fig. 598). A similar procedure is repeated on the left side. Wherever possible at least a small strip of mucosa of the urethra should be left. After enucleating the anterior portion of the prostate on both sides the enucleation is continued from before backward, still

[1]Surg., Gynec. and Obst., February, 1920, p. 182, et seq.

clinging with the finger close to the prostate. After it has been sufficiently loosened the left finger is removed from the rectum, the glove is taken off by a nurse and a fresh glove is put on the left hand. The loosened prostate is caught with sponge holding forceps and moderate, steady traction is made on the forceps while the enucleation is completed. Dry gauze is packed firmly into the cavity left by the prostate and kept in position for three or four minutes.

The clots are removed and the end of the catheter that is within the

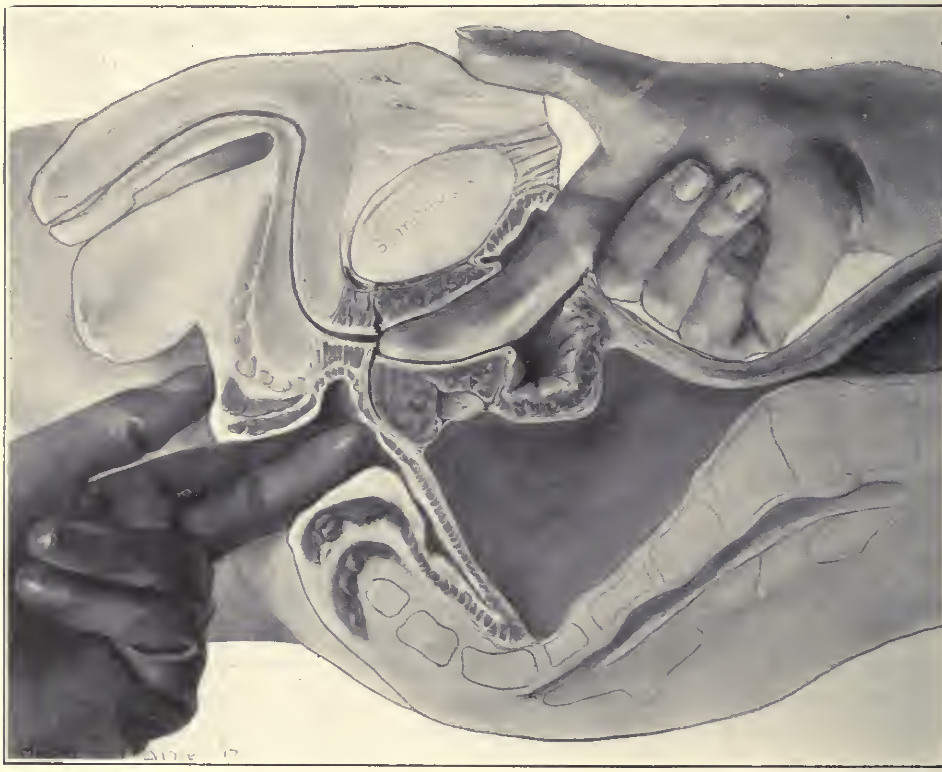

Fig. 597.—Cross section of the first stage of the suprapubic prostatectomy of Squier. The finger is about to break through the roof of the prostatic urethra. (After R. C. Bryan.)

bladder is seized and brought up through the suprapubic wound. A stout black linen thread is tied on the catheter four inches from its tip with a loop knot. Into this linen thread are folded strips of iodoform gauze twisted as a cable. The linen is tied over the gauze, preferably in a bow knot, and the ends are left long. The gauze packing that was in the bed of the prostate is removed, and the iodoform gauze held by the linen thread is gradually introduced into the bladder while an assistant makes traction on the end of the catheter protruding from the penis. The iodoform gauze is molded and packed into the cavity left by removal of the prostate. An end of the gauze and the ends of the linen thread around the gauze are brought out

through the wound. A large rubber tube for drainage is inserted in the bladder at the upper portion of the wound (Fig. 599). If there has not been a previous suprapubic drainage it is best to place a cigarette drain down to the prevesical space. The wound is partly closed by interrupted sutures of silkworm-gut. One suture of silkworm-gut just below the tube is inserted but not tied till after the packing has been removed.

The base of the catheter that protrudes from the urethra is clamped with pedicle forceps, a stout cord is tied to the handle of the forceps and, after the patient has been placed in bed, this cord is carried over the foot of the bed and a two pound weight is attached to it. This weight should be lifted for ten minutes every hour unless there is considerable bleeding. This prevents the continuous ischemia of the tissues that are pressed upon by the gauze. Eight hours after the operation, the weight is removed entirely if

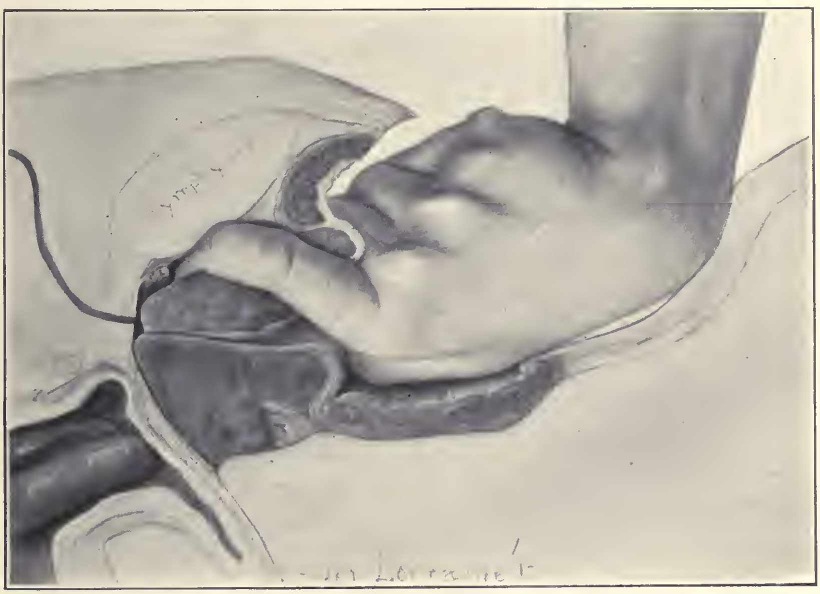

Fig. 598.—The finger has broken through the prostatic urethra and the prostate is being enucleated, beginning at its apex on the right side. (After R. C. Bryan.)

the bleeding has ceased. The gauze is left in place, however, for forty-eight hours and after taking out the drainage tube, is removed by pulling up the ligature around the iodoform gauze. This ligature is either untied or divided with scissors and the gauze is removed. If the gauze has been inserted as a long strip and an end brought out of the wound along with the drainage tube, the removal is easier. A mushroom catheter is inserted and the silkworm-gut suture that was placed at the time of operation, but not tied, is tied and reduces the extent of the wound.

This method of controlling hemorrhage which I have tried in recent cases is usually satisfactory. The gauze can be molded and packed into the cavity

left by removal of the prostate very accurately and it not only checks bleeding more promptly than rubber, but may be made to exert more nearly uniform pressure on the irregular contour of the prostatic bed than an inflatable rubber bag. Besides, it is easy to obtain and is not subject to accidental punctures which may be disastrous with a rubber bag.

Fig. 599.—The prostate has been removed and the drawing shows a satisfactory method of controlling hemorrhage, which is fully explained in the text. The gauze has several obvious advantages over a rubber bag. It has greater hemostatic properties, can be molded more accurately into the bed of the prostate, it can be removed without dragging all of the catheter through the bladder, and it is readily obtainable in any operating room.

When the urethra is irritable, an excellent method of controlling bleeding is to pack the bed of the prostate with a long strip of iodoform gauze and grasp the last portion of the gauze with sponge forceps. By elastic bands going from the handle of the forceps, which protrudes from the wound, to adhesive on the patient's skin, constant pressure is made on the packing.

While the suprapubic route is preferable in most prostatectomies there are certain conditions that have already been mentioned which make the perineal operation of H. H. Young more desirable. Here, a curved incision is made from just in front of one tuberosity of the ischium to a similar point on the other side. It curves forward so the apex reaches just behind the posterior margin of the scrotum. A flap is turned down. A curved sound is inserted into the urethra and, with the finger, blunt dissection is made on each side of the urethra and the rectum is gradually pressed backward. The central tendon and the rectourethralis muscle are divided close to the urethra. The bifid retractor of Young may be used to push the rectum back while these structures are divided, or better still, the rectum can be held back by the index and middle fingers of the left hand. The recto-urethralis muscle holds the rectum very close to the urethra and it is important to avoid injury to the rectum at this point. The bulb of the penis is retracted forward. An injury to it will cause an annoying bleeding. The membranous urethra is exposed and divided by a longitudinal incision down to the sound. Each margin of the wound in the urethra is caught with forceps and the finger is introduced and the bladder explored. Often the finger cannot reach even the limits of the prostate but it will at least serve to dilate the passage and to determine any unusual conditions that may lie within the prostate. The finger is withdrawn and the prostatic tractor of Young is introduced closed. It is spread open and with this tractor the prostate is drawn into the wound. The fascia at the apex of the prostate with the muscle fibers that overlie its capsule are stripped to each side by blunt dissection so that the capsule of the prostate is freely exposed. The rectum is firmly retracted and the prostate steadied by the prostatic tractor while two incisions are made, one on each side of the midline about an inch and a half apart. These incisions are carried from a point external to the insertion of the prostatic tractor downward and backward and are made well into the substance of the prostate. It must be recalled that in this portion of the prostate there is usually a considerable thickness of normal tissue and unless this is cut through to the adenomatous portion of the prostatic enlargement, the true line of cleavage will be missed and not only will the operation be more difficult but it will be unnecessarily bloody.

The capsule of the adenomatous enlargement is demonstrated, and is peeled up by the insertion of a blunt instrument, such as a blunt dissector or the handle of a knife, or closed blunt scissors the blades of which are then spread. After the separation has begun sufficiently to admit the finger without tearing the tissues, the finger is introduced and the enucleation continued. It is best to enucleate partially one lobe, then completely enucleate the other, and after this remove the first lobe. In this way, complete collapse of one side before loosening the other side is avoided. As the enucleation proceeds the prostate is grasped with sponge-holding forceps and pulled down, which aids the manipulations considerably. Traction on

the prostatic tractor also helps. After both lobes have been delivered the prostatic tractor is turned to one side so that any enlargement of the middle lobe may be brought into the lateral incision in the capsule and enucleated.

The prostatic tractor is folded together and withdrawn, and the finger is again inserted into the bladder to determine whether any stones or diverticula are present. The cavity left by removal of the prostate is firmly packed with strips of iodoform gauze. If the prostatic capsule has not been extensively torn by the removal of the prostate the capsule encloses a cavity which can be readily packed. This aids greatly in controlling hemorrhage.

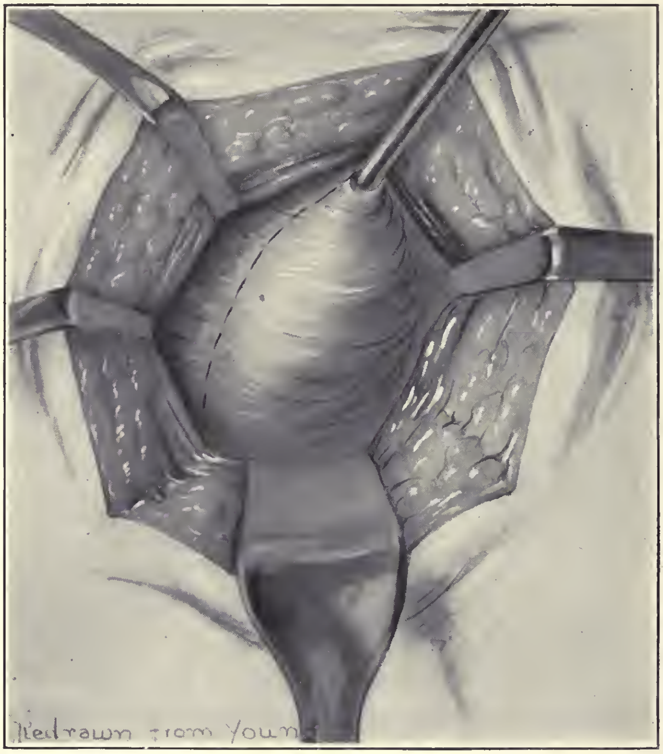

Fig. 600.—The operation of H. H. Young for cancer of the prostate. The urethra has been opened through the perineal incision, the tractor is inserted into the bladder, and the posterior surface of the prostate is cleared, showing the anterior layer of the fascia of Denonvillier. The dotted line shows where the dissection should proceed in order to keep between the anterolateral fascia and the lateral aspect of the prostate.

Unfortunately, however, with a large prostate the mucosa of the bladder is often torn during the enucleation and the gauze cannot always fill the cavity firmly. This is an objection to perineal prostatectomy because in the suprapubic method by the technic already described firm pressure can always be made with gauze. In small firm prostates, however, enough of the capsule can usually be left by perineal extraction to permit satisfactory packing. A large drainage tube is inserted into the bladder through the opening in the membranous urethra and the fascia and fibers of the levator ani muscles are brought together

by one or two sutures of catgut. This point is, according to Young, very important in preventing a rectal fistula and serves to keep the pressure from the rectum. The ends of the gauze packing and the tube are brought out at the left extremity of the wound and not in the midline. The wound is closed by interrupted sutures of silkworm-gut. The bladder is thoroughly irrigated with hot boric acid solution before the patient leaves the table but no other irrigation is done until after forty-eight hours, as this may wash away the elements of the blood which promote clotting. The gauze packing is removed after forty-eight hours and the tube a day later.

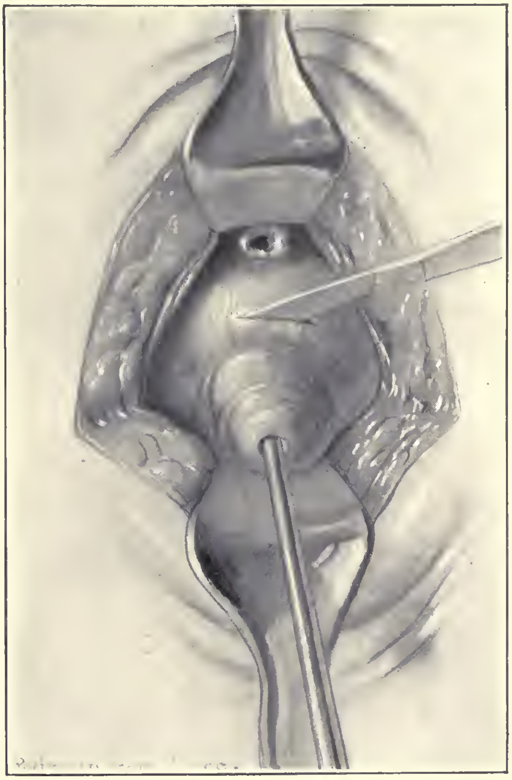

Fig. 601.—The membranous urethra has been completely divided. The prostate is turned down and the bladder wall is incised just above the upper limit of the prostate.

In cancer of the prostate a more radical operation must be done. H. H. Young[2] has devised a technic for radical operation which seems satisfactory from the standpoint of a cure and at the same time gives the patient a moderate degree of urinary control after the operation. The patient is placed in the extreme dorsal position as in the perineal operation for prostatectomy and the procedures are carried out as though a perineal prostatectomy were to be done, up to the step of incising the capsule. After inserting the tractor the prostate is drawn down and the posterior

[2]Young, H. H.: Jour. Am. Med. Assn., 1917, lxix, 1591, et seq.

layer of Denonvillier's fascia is divided at the apex of the prostate on each side, thus exposing the anterior layer of this fascia which covers the prostate and the seminal vesicles (Fig. 600). The posterior surface of the prostate and seminal vesicles is freed and then the lateral surfaces of the prostate are exposed by blunt dissection. The operator keeps within the antero-lateral prostatic fascia, separating it from the prostate, which thus avoids hemorrhage and at the same time preserves the vascular supply and the perineal nerves. This step Young thinks is very important. By resecting the anterolateral fascia and passing between it and the lateral and the anterior

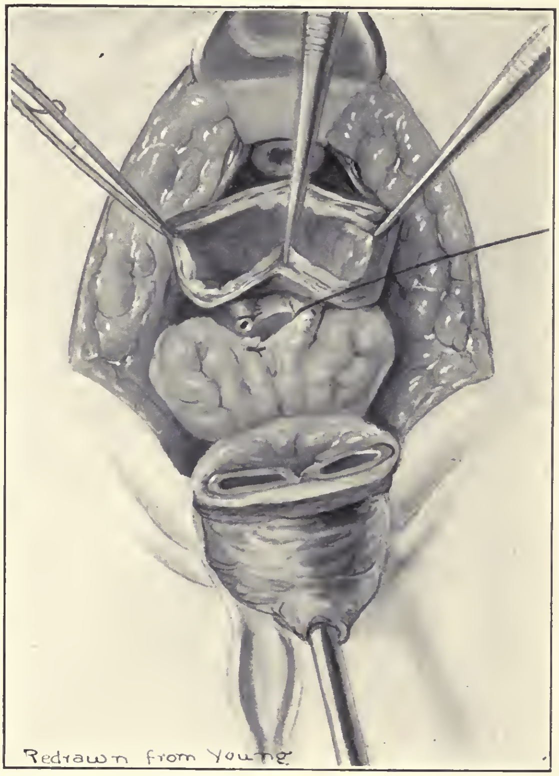

Fig. 602.—The bladder has been completely incised, the vesicles, the vasa and the surrounding tissue are mobilized, and the right vas is divided and tied. Vascular tissues in this region are clamped, if possible, before division.

part of the prostate, a certain amount of urinary control can be preserved. After separating this fascia the membranous urethra is completely divided just in front of the prostatic tractor. Here also the anterolateral prostatic fascia must be respected. The prostate is pulled down and gradually drawn outward (Fig. 601).

The bladder wall is incised anteriorly, close to the upper limit of the prostate, and the incision is continued by scissors on each side. In this manner the trigone of the bladder is fully exposed. The trigone is incised about a third of an inch below the ureteral orifice, in such a way that the walls of

the bladder are carefully cut through but the seminal vesicles beneath are not divided. The bladder is then pushed up bluntly thus exposing the tissues around the front of the seminal vesicles and vasa deferentia. These structures are freed *en masse* and the fascia which contains the blood supply at the upper end of the seminal vesicles on each side is ligated and divided as far as possible from the prostate. The vas deferens is isolated on each side, freed well above the tip of the seminal vesicle, drawn down, clamped and divided (Fig. 602). The mass including the prostate and its surrounding tissue is then removed in one piece.

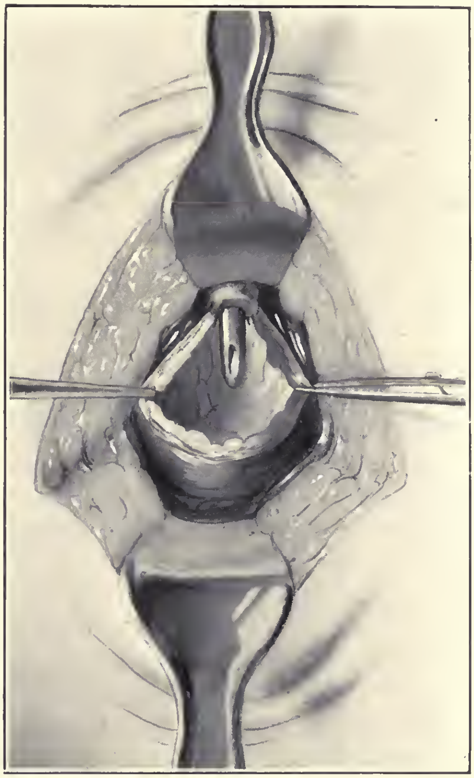

Fig. 603.—The prostate with the surrounding tissue is removed in one mass and the upper border of the bladder wound is sutured to the upper part of the urethra with interrupted sutures of tanned or chromic catgut, and the knots are tied externally. Similar sutures are placed anteriorly and the rest of the bladder wound is closed with a continuous suture.

The bladder is drawn down and the upper portion of the urethra is sutured to the upper portion of the wound in the bladder by interrupted sutures of chromic or tanned catgut, tied externally (Fig. 603). A catheter is then inserted through the urethra and into the bladder and the anastomosis between the urethra and the bladder is completed by interrupted sutures of tanned or chromic catgut. The longitudinal opening in the bladder which remains posterior to the anastomosis with the urethra is closed with a continuous suture of tanned or chromic catgut. A small cigarette drain of iodo-

form gauze is placed behind the line of sutures and the levator ani muscles are brought together by one or two sutures of chromic catgut. The skin is closed in the usual manner. The catheter is left in and fastened to the penis by adhesive plaster. The drainage is removed in two or three days. It is not necessary to pass sounds or instruments after the operation.

In Young's experience many patients after this operation have satisfactory control of the bladder.

THE SEMINAL VESICLES, VAS DEFERENS, AND TESTICLES

Disease of the seminal vesicles may require operation for drainage or, occasionally, for excision of the seminal vesicles. When they are to be opened the operation of Fuller has given good results. The patient is placed in the knee chest position with the knees sharply flexed. An incision is made on each side of the anus, opening up each ischiorectal fossa, and the extremities of these incisions are joined by a transverse incision in front of the rectum. With the left finger in the rectum the rectal wall is separated from the prostate and vesicles by blunt dissection. After the separation a long grooved director is thrust into the apex of the vesicle while using the finger in the rectum as a guide to direct the course of the director. A scalpel is shoved along the groove of the director until it enters the apex of the seminal vesicles and a cut of about an inch and a quarter is made with the blade of the knife along the course of the vesicle, freely laying open its cavity. The incision is dilated with the finger tip. The other seminal vesicle is opened in a similar manner. If there is a considerable mass of granulation tissue the cavity is curetted. Each cavity is packed with strips of gauze, the ends of which protrude from the external wound, and two soft rubber drainage tubes are placed between the gauze and the rectum. The incision is closed with interrupted sutures except at the transverse part which is left open for drainage and for the exit of the tubes and the ends of the gauze packing. The gauze is removed after three days and the tubes four days later.

A better method of operating on the seminal vesicles is through an exposure used by Cunningham, of Boston. Here the vesicles are approached as in a perineal prostatectomy. He does not open the urethra, but depresses the prostate with a fork retractor and fully mobilizes its under surface.

Occasionally it may be necessary to drain the vas deferens. This operation can be readily performed by isolating the vas deferens in the upper portion of the scrotum and, under local anesthesia, dividing it. The upper end of the vas is split and stitched into the wound if it is intended to drain the seminal vesicles also. Reunion of the vas can be made by end-to-end sutures of fine arterial silk after a strand of silkworm-gut has been placed in its lumen and brought out by a needle through the vas at a point about half an inch from the line of union. After placing the sutures the silkworm-gut is left in position and later it may be withdrawn.

Anastomosis of the vas with the epididymis is done in sterility, in which there is a blockage of some portion of the vas or of the epididymis. The epididymis and vas may be satisfactorily exposed through an incision in the posterior part of the scrotum. The veins and larger blood vessels should be avoided. Before undertaking this operation any stricture that may be in the urethra or inflammation of the seminal vesicles should be cured and the patency of the vas from the epididymis to the prostatic urethra should be demonstrated by injecting into the vas methylene blue and noting if it appears in the urethra. The vas is exposed and split longitudinally and about twenty or thirty drops of methylene blue are slowly injected. The dye will appear in the urine if there is no obstruction or in the seminal discharges after massage of the seminal vesicles. If this test is satisfactory the epididymis is opened by cutting off a small piece with a pair of scissors. It must be demonstrated by a microscope that the fluid within this portion of the epididymis contains spermatozoa, and if they are not found at this point other openings must be made into the epididymis or into the testicle until spermatozoa are found. The widely split vas is then sutured with a few interrupted sutures on a fine needle to the opening in the epididymis or testicle. Arterial silk is an excellent suture for this purpose.

Anastomosis of the vas and the epididymis done by the method described, which was devised by Martin, of Philadelphia, is more or less indirect. After the capsule of the epididymis has been incised and a portion of the epididymis tubule cut the vas is split and the open incision in the vas is sewed to the capsule of the epididymis over the raw surface of the incised tubule of the epididymis. There is consequently considerable distance to be bridged by the epithelium lining the vas and the epididymis.

V. D. Lespinasse,[3] of Chicago, has devised an operation which is a direct anastomosis between the epididymis tubule and the vas. An incision is made in the scrotum and through the tunica vaginalis. The epididymis is exposed and the point of obstruction is found. The vas is opened by a short longitudinal incision and a colored fluid, as methylene blue, is injected into the central end of the vas. If the fluid appears in the urethra it is a demonstration that the vas is open from the point of incision to the urethra and the operation can be proceeded with. If the vas is not open the operation, of course, will be abandoned unless the point of occlusion can be found farther up. If the operation is to be completed the capsule of the epididymis above the obstruction is carefully incised down to the tubule. All of the layers of the capsule are removed from the epididymis tubule with great care and the epididymis tubule itself should not be injured or opened at any point. It protrudes through the opening thus made and a loop of the tubule is selected whose direction is in the long axis of the body of the epididymis. A suture of fine arterial silk (00000) on a No. 19 bayonet pointed needle is passed through the wall of the epididymis tubule, down its lumen, and out again through the wall of the tubule about three mm. from the point

[3] Lespinasse, V. D.: Jour. Am. Med. Assn. lxx, Feb. 16, 1918, p. 448 et seq.

of entrance (Fig. 604). This is followed by leakage of epididymal secretion which is drawn into a small syringe and examined for spermatozoa. If spermatozoa are present this suture is passed through the incision that has been previously made into the vas and out through its wall. The other end of the suture is threaded into a needle and passed through the wall of the vas in a similar manner at the other end of the incision in the vas. In this way the epididymis tubule is drawn into the longitudinal incision in the vas (Fig. 605). Sutures of catgut are placed on each side of

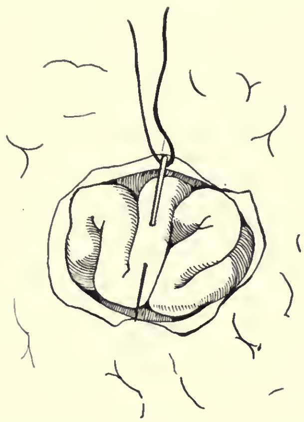

Fig. 604.—The operation of Lespinasse for anastomosis of the vas and the epididymis. A fine silk suture is inserted into a tubule of the epididymis.

Fig 605.—The suture in the tubule is carried through the incision in the vas, as explained in the text. (Lespinasse.)

Fig. 606.—The other sutures are placed to hold the vas to the capsule of the epididymis. (Lespinasse.)

the longitudinal incision in the vas, include the full thickness of the wall of the vas, and are carried to the capsule of the epididymis. These hold the incision in the vas open. Two other sutures are placed into a portion of the wall of the vas but do not penetrate to its lumen or epithelial lining and hold the vas to the capsule of the epididymis a short distance from the ends of the longitudinal incision into the vas (Fig. 606). When these two sutures are tied they should leave the intervening segment of the vas without tension so that the union between the vas and the epididymis tubule is in accurate approximation and without strain. The upper end of the

original suture is threaded on a long hagedorn needle and after the testicle has been replaced in the scrotum the needle pierces the scrotum from within outward. In from one to two weeks when the wall of the epididymis tubule within the grasp of this suture has become cut by this suture it is gently removed.

In tuberculosis of the epididymis, the epididymis can often be excised without removing the body of the testicle, if the disease is not too far advanced. The incision is made through the scrotum, external to the epididymis or if the epididymis is adherent to the skin the tissue that is bound by the adhesions is included in an oval incision. An incision along the junction between the epididymis and testicles is made on the outer side and divides only the tunica vaginalis opposite the body of the epididymis but goes deeper at the globus major and globus minor. The head of the globus major is separated by sharp dissection from the testicle and then the body of the epididymis is freed. All of this dissection is from the outer side. On the inner side the large vessels to the testicle are in contact with the epididymis and dissection here must be particularly careful. By traction the structures of the cord are recognized and injury to the vessels may be avoided. The dissection is continued by separating the vas up to the internal ring. Here it is doubly clamped and divided, the proximal end is cauterized with carbolic and ligated. Any other foci of the disease are excised. After controlling the bleeding by suturing the tunica and the raw surface with catgut, the external wound is closed with interrupted or continuous mattress sutures of fine tanned catgut.

In epididymitis incision of the epididymis often gives relief when nothing else will. It will probably require a general anesthetic. An incision is made through the scrotum either over the epididymis or in the upper front part of the scrotum so that the testicle can be delivered into the wound. The epididymis is punctured a number of times with a large needle and returned to the scrotum. If there is suspicion of pus the scrotum is incised immediately over the epididymis which is punctured in several places.

Removal of the testicles may be necessary for tuberculosis or for a benign or malignant growth. An incision is made over the front upper part of the scrotum from the level of the external abdominal ring downward for a sufficient distance to deliver the diseased testicle into the wound. Such an incision is usually all that is necessary in tuberculosis or in benign tumors. The cord is doubly ligated with catgut after being crushed and the testicle is drawn up into the wound and removed. It is necessary to clamp and tie every bleeding surface. The wound is closed by a continuous mattress suture of fine tanned catgut.

If there is distinct malignancy the operation should be radical. An incision is made over the inguinal canal from a point one inch external to the internal ring, downward over the external ring, and onto the scrotum. The inguinal canal is exposed as in the operation for hernia and the flaps of the aponeurosis of the external oblique are retracted. The vas is dissected from

its bed and followed as far as possible into the pelvis after dividing the posterior wall of the inguinal canal. The vas deferens is then doubly ligated, divided and the stump is cauterized. The spermatic vessels are followed up into the lumbar region, all of this being done extraperitoneally. They are doubly ligated and divided. The other tissues of the cord are divided and the cord is dissected down to below the external inguinal ring. The testicle with the tumor and surrounding tissues is delivered into the wound and removed along with the cord. As much tissue as possible is taken and if any part of the scrotum is adherent this portion should be removed along with the testicles, the original incision being continued downward so as to include the adherent part of the scrotum. Every bleeding point is clamped and tied with fine catgut.

Undescended or misplaced testicle is best treated by the general principles of the Bevan operation. Here the incision is made as in the radical operation for inguinal hernia and does not involve the scrotum. After exposing the inguinal canal the cremaster muscle and the fascia are divided, the sac of peritoneum which contains the testicle is opened and the undescended testicle exposed. The peritoneum above the testicle is separated from the cord very carefully and the upper portion is divided and closed by sutures or a ligature as in tying a hernial sac. The lower pouch of peritoneum serves as a tunica vaginalis and is closed around the testicle loosely with a pursestring suture. The testicle with its covering sac is lifted from its bed and gentle traction is made on the cord. This demonstrates the bands that prevent the descent of the testicle into the scrotum. These bands are usually connective tissue and can be cut with scissors or torn with forceps. The cord is so dissected that only the blood vessels and the vas are left and these are separated from the posterior layer of the peritoneum by blunt dissection as far as possible. In this way the cord is lengthened for several inches. A thorough lengthening of the cord is an important step in the operation. The finger is inserted into the scrotum and burrows a pocket for the testicle. This pocket is enlarged by pushing down closed pedicle forceps and spreading the blades. The testicle is inserted into this pocket and is held by a pursestring suture passed through the pillows of the external inguinal ring but tied lightly so as not to compress the circulation of the cord. The wound is closed by shoving the cord to the inner angle of the wound and uniting Poupart's ligament with the conjoined tendon over the cord.

When it is impossible to bring the testicle into the scrotum by this means some of the spermatic vessels which are the chief obstacle to its descent may be divided. This, however, is of doubtful expediency, for while the testicle may not actually undergo gangrene, division of the spermatic vessels so profoundly affects its nutrition that it will probably atrophy. Gessner, of New Orleans, has demonstrated experimentally that atrophy of the testicle follows ligation of the spermatic vessels.

Hydrocele may often be cured by the simple method of tapping the hydrocele with a large aspirating needle or a small trocar and cannula and in-

jecting from ten to thirty drops of pure carbolic acid after drawing off all of the fluid. In tapping the hydrocele a point is selected on the anterior surface of the scrotum that is free from veins. While the hydrocele is steadied with the hand a small amount of novocaine solution is injected into the scrotum and a short incision of about one-quarter of an inch is made with a knife. Through this incision a large aspirating needle or a small trocar and cannula are inserted. The trocar is withdrawn, the fluid evacuated and the carbolic is slowly injected through the cannula. The skin surrounding the point of puncture is anointed with vaseline to protect it from the carbolic when the cannula is withdrawn. The cannula is then quickly removed, while grasping the punctured scrotum with a piece of gauze which will absorb any carbolic that may leak from the end of the cannula. The scrotum is gently massaged to distribute the carbolic evenly over the inner surface of the tunica vaginalis. Carbolis is less painful for injection and less dangerous than iodine.

Considerable swelling follows this procedure which gradually subsides in most cases. If it has not all disappeared in three weeks the injection may be repeated. This procedure will cure many cases of simple hydrocele.

If the hydrocele is not cured after two or three injections at intervals of several weeks the sac is excised or everted. Eversion of the sac, or the so-called bottle operation, is done by making an incision through the anterior surface of the scrotum. The testicle is delivered into the wound, the sac opened, and its edges are sutured behind the testicle so as to turn its inside out and appose the whole of its interior to the raw surface of the wound which will usually absorb the secretion from the sac. In many cases, however, pockets form and this operation is not satisfactory. Excision of the sac necessarily gives the largest number of cures of hydrocele and if carbolic injections have not been successful excision, particularly in a large thick sac, is the operation of choice. An incision is made through the anterior surface of the scrotum down to the hydrocele sac. The various coverings are separated until the sac is reached but not opened. It is then bluntly dissected free from its surroundings as far as possible and delivered into the wound. Occasionally the hydrocele sac is of such a nature that it can be dissected free and removed without being opened. This, of course, is an anatomic peculiarity and does not often occur. After freeing as much of the sac as possible it is opened and trimmed away close to the testicle, taking care to leave no redundant fold. The vessels are clamped and tied and the scrotal wound is closed with a continuous mattress suture which everts the edges of the skin wound and prevents the dartos muscle from pulling it in.

An operation for varicocele should be performed only when enlargement of the veins of the cord is marked and has resisted medical treatment for many months. It should not be done in a youth about the age of puberty except when the disease is very marked and the symptoms are decided. When it is necessary to remove varicose veins resection of the scrotum is also indicated. A varicocele that is not sufficiently pronounced to be accompanied

with a markedly relaxed scrotum does not, as a rule, require operation. It is just as essential to remove the redundant scrotum and so afford support to the testicle as it is to remove the enlarged veins.

The scrotum is caught with an Allis forceps in the median raphe at about the junction of its upper and middle thirds and also at the junction of its middle and posterior thirds. The scrotum is lifted up and the redundant portion is clamped with pedicle forceps. This part is cut away with scissors while making tension upon it. The incision is just on the proximal side of the forceps so the tissues that are injured by the clamp are excised. The bleeding vessels are quickly caught with hemostats. Every bleeding point must be clamped. After complete hemostasis has been secured with the clamps, the vessels are tied with fine plain catgut. The varicose veins over the left cord are exposed by an incision along the cord and the vas deferens, together with the spermatic artery, are freely delivered into the wound. The spermatic artery is identified if possible. If this can be done the spermatic artery with one or two veins and the vas deferens are gently isolated and separated from the rest of the dilated veins, but if it is impossible the largest varicose veins are freed and about three inches are removed after doubly ligating with catgut the upper and lower portions of the veins. If the spermatic artery can be recognized and isolated along with the vas deferens and a few other veins the rest of the veins may be safely removed after ligating them with catgut close to the testicle below and at the upper portion of the scrotum. It is best to put two ligatures on each end to avoid the possibility of the ligature slipping. The ends of one set of ligatures are left long. After excising the intervening segment of vein the stumps are tied together by the long ends of the ligatures.

When in doubt it is much better to take out too few veins than too many, as the resection of the redundant portion of scrotum will give such support to the testicle and structures of the cord that extreme radical procedures in removal of veins of the cord are not necessary. It is highly important to leave the spermatic artery for, as has already been mentioned, the excellent experimental work of Gessner, of New Orleans, has demonstrated the probability of complete atrophy of the parenchyma of the testicle after ligation of the spermatic artery. After carefully securing all bleeding points and tying them with fine catgut the wound is closed with a continuous mattress suture of tanned catgut. The suture is applied in the line of incision. A second row of sutures uniting the edges of the skin may be placed to secure more accurate apposition. Such a wound makes a scar that resembles very closely the median raphé and if the incision has been properly made there are no teats or irritating protuberances that often follow a transverse incision for removing the redundant scrotum.

External urethrotomy for deep strictures has already been described. Internal urethrotomy is but seldom practiced. Occasionally, however, there may be a marked decided narrowing of the external meatus which it is neces-

sary to split. This is done under local anesthesia by injecting the tissues around the meatus and incising the meatus at its lowest point.

Circumcision may be done under local anesthesia. If on an infant care must be observed to see that the adhesions between the glans penis and the prepuce are well separated. By cutting down the prepuce without separating these adhesions anteriorly, the meatus may be split and the glans injured, which will be followed by considerable bleeding. The prepuce is grasped anteriorly on each side of the midline by two small hemostats. Slight traction is made and if there is any reason to expect adhesions between the glans and the prepuce a pair of curved scissors is inserted within the prepuce and gently spread so as to separate the adhesions sufficiently to make a dorsal incision in the prepuce without injuring the glans. A straight incision is then carried down the dorsum of the prepuce to a point about opposite the corona (Fig. 607). This must be determined before too much traction is made upon the prepuce, as otherwise the incision may be carried too far. Any further

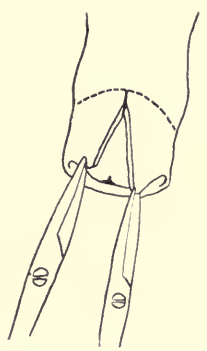

Fig. 607.—The first stage of circumcision. The dorsal incision is made and the dotted line shows the incision for removal of the prepuce, which should be just distal to the corona.

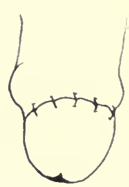

Fig. 608.—The circumcision is completed.

adhesions are now thoroughly separated and the prepuce is trimmed from the upper extremity of this dorsal incision around to the frenum on each side parallel with the corona. Sufficient tissue should be left at the frenum to allow for suturing without contraction. The bleeding points are caught with mosquito forceps and tied with fine catgut. The wound is closed with a continuous suture of fine tanned or chromic catgut which begins on the right of the frenum, is carried around the incision and terminates a short distance from its beginning (Fig. 608). This leaves a slight interval between the beginning and the end of the suture, which allows for swelling or erection. If the tissues in the frenum are not entirely covered by this suture one or two additional interrupted sutures of fine catgut are placed.

In epispadias the urethra is merely a groove on the dorsum of the penis. Such a deformity often accompanies exstrophy of the bladder and as the best operation for exstrophy of the bladder is transplantation of the ureters, the

chief object of the operation for epispadias in the presence of exstrophy of the bladder will be for sexual intercourse.

The operation of Cantwell is probably the most satisfactory operation for epispadias. This depends upon the fact that in this disease the two corpora cavernosa are much more loosely attached to each other than in a normal penis and can be readily separated. The first step in this as in any plastic operation on the penis is to provide for drainage of the bladder, either through the perineum or suprapubically, in order to divert the stream of urine while the wound in the penis is healing. The perineal operation is best here and can be quickly done by a short incision through the perineum on a sound in the urethra. On each side of the groove of the epispadias that represents the urethra an incision is made along the junction of the mucosa and the skin extending from the symphysis to the extremity of the glans. These incisions extend down to the corpora cavernosa but not into them. The urethra is freed as a flap from its bed and held up while the two cor-

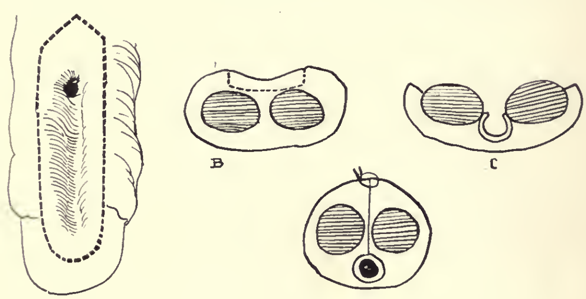

Fig. 609.—The operation of Cantwell for epispadias. *A*, shows the epispadias, with the dotted line indicating the incision for the formation of the urethra. *B*, shows the relation of the skin flap which is to form the new urethra. The corpora are not firmly attached to each other in epispadias. *C*, the flap for the urethra is made and is sunk between the two corpora which are easily separated in this deformity. *D*, cross section representing the operation completed.

pora cavernosa are separated from each other until the skin on the lower surface of the penis is reached. The mobilized urethra is now placed in the bottom of this wound and fixed by sutures. A sound is laid in the urethra and the skin of the urethra is sutured over it. The corpora cavernosa are brought together by a few sutures and the skin is closed over them in the usual manner. The illustrations show the steps of the operation (Fig. 609). The base of the flap of the urethra is at the root of the penis so that there should be no trouble about the nutrition of this transplanted mucosa of the urethra.

Hypospadias is more common than epispadias and may exist in various degrees. When the defect is slight the operation of Beck may be done. An incision is made around the urethral orifice and over the under surface of the urethra toward the perineum. The urethra with the corpus spongiosum is dissected from the corpora cavernosa for a sufficient distance so that it can be readily drawn through a stab wound in the glans penis. A stab wound is made with a sharp narrow knife and the urethra is brought through

and fastened by a few sutures to the edges of the artificial meatus. The skin is then sutured over that portion of the urethra that has been transplanted. This operation can only be done when there is a very slight defect and but little curvature of the penis. If there is a marked contraction the operation of Beck is likely to reproduce it.

If the penis is bowed the first procedure is to straighten it. This may be done by a transverse incision on the under surface of the penis just behind the glans and the incision is sutured longitudinally. When this deformity is marked the operation of straightening the penis should be undertaken some time before the plastic operation is done for constructing the urethra.

J. E. Thompson,[4] of Galveston, Texas, has described the embryology of hypospadias together with plastic procedures for correcting this deformity is a very excellent article. As he has said it is important that no skin which contains hair follicles should be used for construction of the urethra.

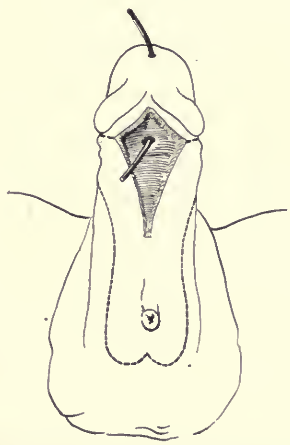

Fig. 610.—The Thompson-Russell operation for hypospadias. The penis is straightened by a transversed incision which by traction becomes diamond shaped. A tunnel is made in the head of the penis which is enlarged later on. The dotted lines indicate the incision for the flaps.

An operation that can often be done and which gives satisfactory results is that of C. H. Mayo. After straightening the penis the wound is allowed to heal and at the second operation a large tunnel is made through the glans penis to a point a little to one side of the site of the normal opening. A flap long enough to reach without tension through this tunnel in the glans to the urethral opening is cut from the dorsal surface of the penis and prepuce with its base at the anterior margin of the prepuce. It must be wide enough to be rolled into a tube of about the size of a normal urethra. It is sutured together as a tube with the skin surface inside, using fine sutures of tanned or chromic catgut. This tube is drawn through the tunnel in the glans, and the tip is sutured to a bed prepared for it close to the urethral opening. The tube is allowed to heal in position and after an interval of a few weeks the

[4]Thompson, J. E.: Tr. Southern Surg. Assn., 1916, p. 223, et seq.

base of the flap is cut. A few weeks later this tube made from the transplanted fold of prepuce is united to the end of the urethra.

In the operation of Russell, flaps are taken from the side of the penis adjoining the groove which represents the defective part of the urethra. In all of these operations perineal drainage of the bladder must be the first stage. In Thompson's modification of the Russell operation the penis is first straightened by a transverse incision just under the glans. The penis being straightened, a large tunnel is made through the glans with a narrow-bladed knife (Fig. 610). This tunnel, which begins about the normal site of the meatus, emerges a short distance below the glans. An incision is carried around the penis in the prepuce about one-eighth of an inch from the corona. A second incision is made in the skin of the penis beginning one-eighth of an inch be-

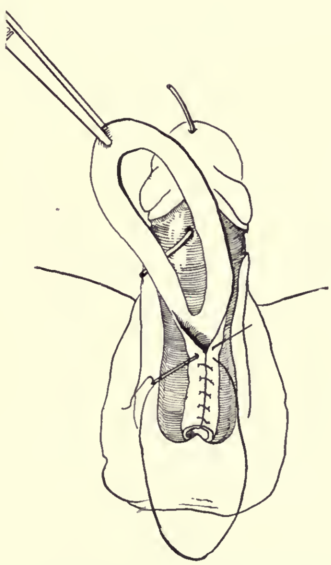

Fig. 611.—The flaps are dissected and are united, so forming the new urethra. (Thompson-Russell.)

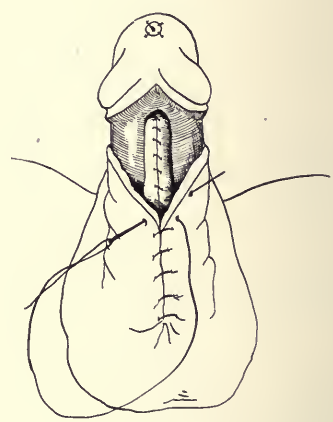

Fig. 612.—The new urethra is brought through the enlarged tunnel in the head of the penis. The lower skin incision is sutured over the new urethra (Thompson-Russell).

hind the urethral opening, and curving backward and outward on each side around the urethral opening. It is then carried forward about one-third of an inch from the margin of the urethral opening and parallel to the groove which represents the defective part of the urethra. This incision is carried over the dorsum of the penis and along the prepuce from one side to the other, parallel to and behind the incision that has been previously made in the prepuce. The dorsal part of this incision is parallel to and behind the first incision made through the prepuce, so these two incisions form a flap of the prepuce which resembles a clergyman's stole. This flap is about one-quarter of an inch wide. It is carefully dissected so as not to separate the outer edges of the posterior portion of the flap any further than possible.

In this way the vascular supply of the flap will be preserved. The skin surfaces of these flaps are turned to face each other and the edges are sutured with fine tanned or chromic catgut. The suturing is so applied as to turn in the skin edges (Fig. 611). The tube, which is formed by suturing these flaps, is drawn through the tunnel in the glans and is fastened in position with a few sutures. The margins of the skin on the side of the penis are sutured together over this urethra from behind forward so as to cover the urethra as far as the glans (Fig. 612). The defect left on the prepuce by raising this flap is easily corrected by suturing the margins of the skin on the prepuce together (Fig. 613). One advantage of the operation is that it can often be done in one stage.

Amputation of the penis may be partial or complete. Before beginning amputation of the penis, the cancerous area is thoroughly cauterized with the actual cautery. This not only prevents infection by sterilizing the septic tissues but guards against an even greater danger of implantation of

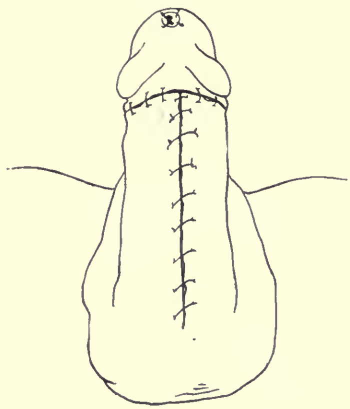

Fig. 613.—The completed operation (Thompson-Russell).

the cancer cells in the raw surface. In amputation, after applying a tourniquet at the root of the penis an incision is made through the skin completely around the penis and about three-fourths of an inch or more from the apparent border of the disease. The skin is dissected back for half an inch and the dorsal artery and vein are exposed, ligated and divided. Both corpora cavernosa are divided transversely and the urethra with its surrounding tissue is divided half an inch in front of the corpora cavernosa. The ends of the corpora cavernosa are whipped over with catgut sutures to control the bleeding. A short incision is made in the skin just over the urethra, which is slightly split opposite this point and is sutured to this incision in the skin.

Usually it is wise to dissect both inguinal regions whenever the penis is amputated for cancer. This is done by making an incision parallel with Poupart's ligament and just above it. The upper margin of the skin is retracted and the fat and fascia are dissected down to the aponeurosis of the

external oblique. This mass of tissue is dissected with gauze down to the border of Poupart's ligament. At the outer extremity of the incision the mass is dissected to the fascia lata and then inward to the tissues over the femoral artery. Dissection is then begun at the inner portion of the wound and is carefully carried toward the femoral canal. Care is taken to avoid injury to the saphenous vein, or at least to recognize it and clamp it before it is divided, if it appears to be involved. By working along the plane of the fascia lata and the aponeurosis of the external oblique block dissection can be readily accomplished. The region at the femoral canal requires careful dissection with a good light and a sharp knife. The mass is finally freed from the femoral artery and vein.

If the inguinal region is to be dissected for cancer it should be done as a block dissection that has just been described. This, however, is unnecessarily radical in inflammatory conditions, and while it is really easier than removing isolated glands there is a danger of edema of the scrotum following the block dissection if done on both sides.

When complete amputation of the penis is necessary the scrotum is split along its median raphé which gives thorough exposure of the corpus spongiosum. The corpus spongiosum is separated from the corpora cavernosa and divided. The urethra is dissected as far as the triangular ligament. The incision is carried around the root of the penis, the suspensory ligament is divided, and the crura are separated from the pubic bones. The vessels of the crura are clamped and tied. The urethral stump is split and the edges of the urethra are sutured to the posterior part of the scrotal wound. The skin is closed in the usual manner after providing for drainage. Both inguinal regions should always be dissected when cancer is sufficiently advanced to require complete amputation of the penis.

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